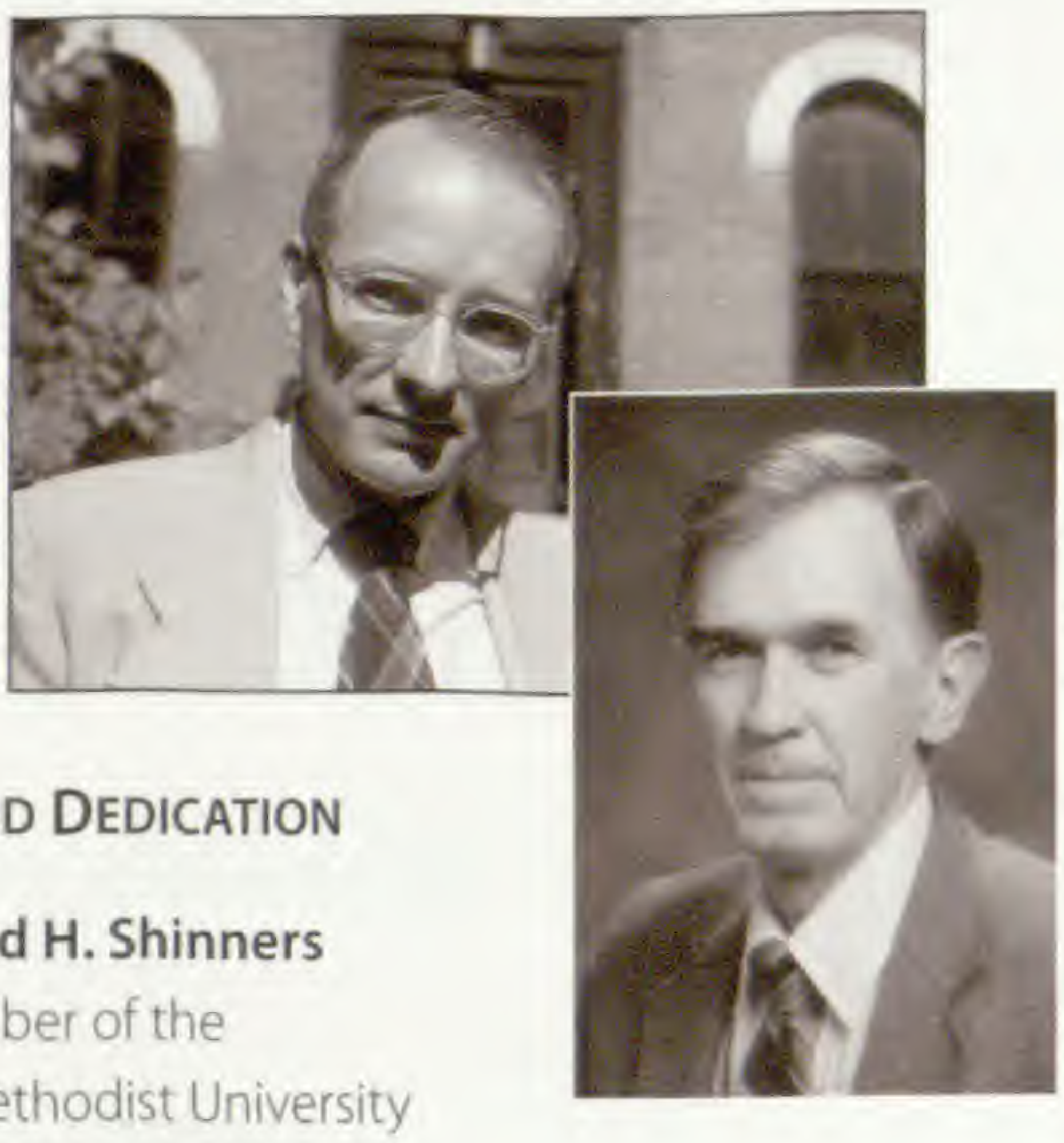
JOURNAL OF THE BOTANICAL RESEARCH INSTITUTE OF TEXAS

J. Bot. Res. Inst. Texas *ISSN 1934-5259*

VOLUME 6 **NUMBER 1** **26 JULY 2012**



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BIBLIOGRAPHICAL

Citation abbreviation for the *Journal of the Botanical Research Institute of Texas* is *J. Bot. Res. Inst. Texas* following the principles of B.P.H. (informally *JBRIT*). International Standard Serial No. (ISSN 1934-5259)

FREQUENCY OF PUBLICATION

J. Bot. Res. Inst. Texas is published semiannually (summer/fall) as one volume by the Botanical Research Institute of Texas.

COPYRIGHT 2012
Botanical Research Institute of Texas (BRIT)
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Fort Worth, Texas 76107-3400, USA

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SUBSCRIPTION PRICES (2012)
$46. Personal (Individual/Family)
$110. USA (Institutional)
$120. Outside USA (Institutional)

SUBSCRIPTIONS/BACK VOLUMES
J. Bot. Res. Inst. Texas and *Sida, Contr. Bot.*
Publications Assistant
Botanical Research Institute of Texas
1700 University Dr.
Fort Worth, Texas 76107-3400, USA
Electronic mail: orders@brit.org

COMPOSITION
rhorngraphics, Plano, Texas; rlrchorn@verizon.net

PRINTING
Prepress production and printing in the United States of America by Millet the Printer, Dallas, Texas
www.milletthepriner.com

COVER ILLUSTRATION
Electronically tinted botanical illustration of *Liatris aestivalis* originally used on BRIT's anniversary poster 2001. Summer gayfeather flowers mid Jul–Aug(–Sep) and is endemic to Oklahoma and Texas.
Sida 19:768. 2001.
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PENSTEMON KRALII (PLANTAGINACEAE), A NEW SPECIES FROM ALABAMA AND TENNESSEE, WITH AN UPDATED KEY TO THE SOUTHEASTERN U.S. TAXA

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ABSTRACT

Penstemon kralii, a new species of *Penstemon* subgenus *Penstemon* section *Penstemon*, is described from the limestone slopes of the southwestern escarpment of the Cumberland Plateau of northeastern Alabama and southeastern central Tennessee. This narrow endemic appears to be allied with *P. tenuis* and *P. smallii*. A key differentiating this new species from all southeastern U.S. *Penstemon* is provided.

RESUMEN

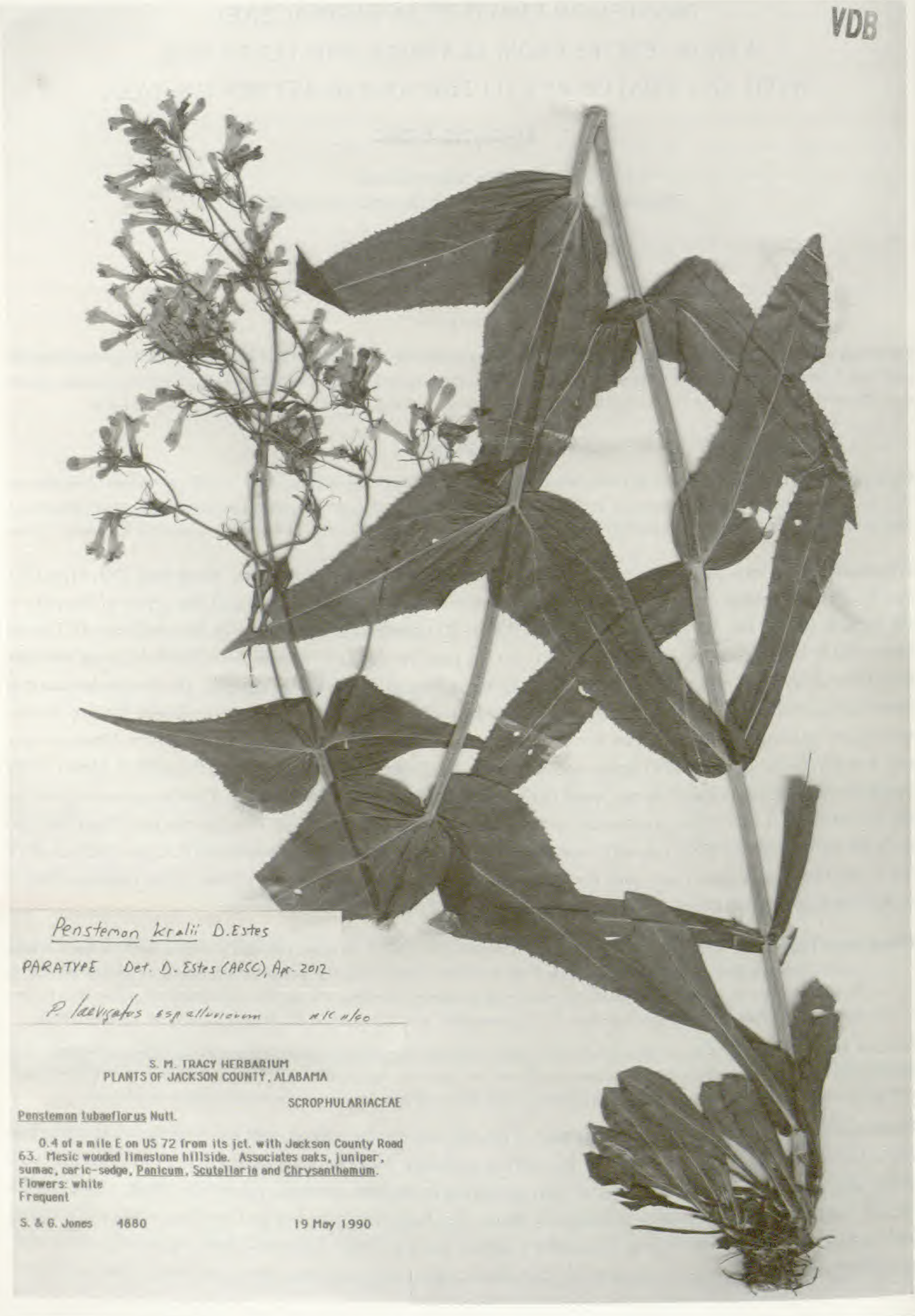
Penstemon kralii, es una nueva especie de *Penstemon* subgénero *Penstemon* sección *Penstemon*, que se describe de las laderas calcáreas del suroeste del Cumberland Plateau en el noreste de Alabama y sureste de Tennessee central. Este endemismo restringido parece esta relacionado con *P. tenuis* y *P. smallii*. Se aporta una clave para diferenciar esta nueva especie de todos los *Penstemon* el sureste de los Estados Unidos.

Penstemon Schmidel is the largest vascular plant genus endemic to North America. More than 250 of the 270+ species of this taxonomically challenging genus occur in western North America with the center of diversity in the Intermountain Region (Wolfe et al. 2006). About 20 species occur naturally in the southeastern United States. Many new species have been described over the past few decades from western North America but none have been described from eastern North America since Pennell's (1935) monograph, *The Scrophulariaceae of eastern temperate North America*. During a recent examination of *Penstemon* specimens for the *Flora of Tennessee* project, specimens of an unusual *Penstemon* from just across the state line in northeastern Alabama were encountered that did not fit any known species. These specimens bore a similarity to *P. smallii* A. Heller of the Southern Appalachians and *P. tenuis* Small of the southern Mississippi River Valley. Further assessment led to the determination that these populations represent an undescribed species. This species joins *Blephilia subnuda* Simmers & Kral (1992), *Clematis morefieldii* Kral (Kral 1987), *Polymnia johnbeckii* D. Estes (Estes & Beck 2011), *Silphium brachiatum* Gatt., and *Vernonia flaccidifolia* Small as the latest addition to the endemic flora of rocky limestone woods of the southwestern escarpment of the Cumberland Plateau.

Penstemon kralii D. Estes, sp. nov. (**Figs. 1–2**). TYPE: UNITED STATES. ALABAMA. Jackson Co.: 3.8 km S of Paint Rock, eastern base of Keel Mountain at the western edge of the Paint Rock River Valley, along NW side of County Road 5, 1.6 km by road W from jct. with US Hwy 72, edge of dry deciduous forest over Mississippian limestone, 34.626176° N, -86.329163° W, 4 May 2011, *D. Estes 11,900 with D. York and C. Gorman* (HOLOTYPE: MO; ISOTYPES: APSC, GH, KANU, NCU, NY, PH, RM, TENN, UC, US, UNA, VDB).

Penstemon kralii differs from *P. tenuis* in its generally wider leaves, paler lavender to nearly white corollas with prominent (sometimes faint) purple guide lines, preference for rocky, calcareous woodlands, and Southern Appalachian distribution. *Penstemon kralii* differs from *P. smallii* in its much smaller corollas that are pale lavender to nearly white and in its lance-attenuate and strongly recurved sepals.

Plant a perennial herb from a caudex. **Stems** 4–7 dm tall, erect to ascending, solitary or clustered, unbranched below inflorescences, terete, 4–5 mm in diameter at midstem, with 6–9 leafy nodes below inflorescence, pale green, densely to moderately puberulent with spreading or retrorse, straight, eglandular, sharp-tipped white hairs 0.1–0.3 mm, the eglandular pubescence above the distalmost non-bracteal leaf becoming more sparse and replaced by mostly spreading, glandular-capitate hairs 0.5 mm. **Leaves** simple, oppositely-decussate, spreading, often with apices recurved in life (not often evident in specimens), proximal oblanceolate and taper-



Penstemon kralii D.Estes

PARATYPE Det. D. Estes (APSC), Apr. 2012

P. laevigatus ssp alluviorum RK 11/60

S. M. TRACY HERBARIUM
PLANTS OF JACKSON COUNTY, ALABAMA

SCROPHULARIACEAE

Penstemon tubaeflorus Nutt.

0.4 of a mile E on US 72 from its jct. with Jackson County Road 63. Mesic wooded limestone hillside. Associates oaks, juniper, sumac, caric-sedge, Panicum, Scutellaria and Chrysanthemum.
Flowers: white
Frequent

S. & G. Jones 4880 19 May 1990

Fig. 1. Paratype of *Penstemon kralii* from Jackson Co., Alabama (*S. & G. Jones 4880* VDB).

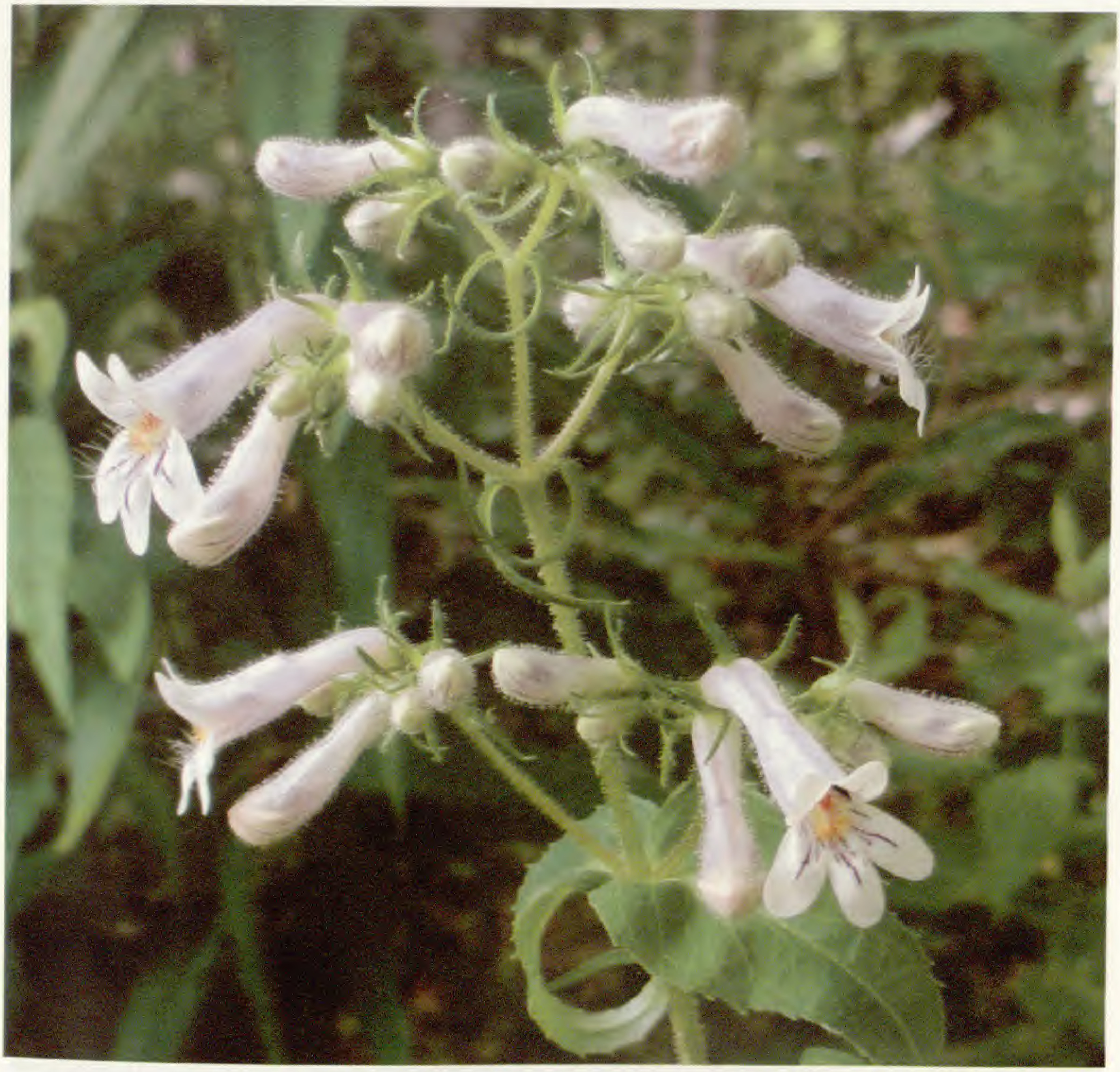


Fig. 2. Inflorescence of *Penstemon kralii*, Franklin County, Tennessee (based on *Estes 11,901 with York & Gorman* APSC, TENN). Photo taken by Dawn York, 4 May 2011.

ing to a narrowly attenuate petiole-like base, medial lanceolate or oblong, those just proximal to the inflorescence ovate-lanceolate, medial blades 12–15 cm × 3–4 cm, usually larger than proximal and distal cauline leaves, apex acute to acuminate, margins sharply and coarsely serrate with mostly 4–7 acuminate teeth per cm (fewer on proximal leaves), base subcordate to rounded and clasping (proximal leaves tapered to a narrowly clasping base); blades dark green, abaxial surface glabrate or those toward inflorescence moderately pubescent; adaxial surface with scattered, eglandular, straight, sharp-tipped white hairs 0.1–0.3 mm, especially near midvein, otherwise glabrate. **Inflorescence** a terminal thyrse, 5–20 cm × 3–12 cm, bracts at base of inflorescence 3–6(–8) cm × 0.7–3 cm, half to sometimes equaling the distalmost non-bracteal stem leaves, primary inflorescence bracts narrowly lanceolate with dilated bases, secondary inflorescence bracts narrowly lanceolate to linear, sometimes abruptly dilated at base; inflorescence glandular-capitate. **Flowers** slightly nodding; pedicels 1.5–4 mm, pubescent with glandular-capitate hairs. **Calyx** campanulate with 5 subequal sepals; these distinct nearly to base, lance-attenuate and becoming strongly recurved, green with thin hyaline margins proximal to middle, 4–5.5 mm × 1 mm, abaxial surface and margins moderately covered with gland-tipped hairs, adaxial surface glabrous. **Corolla** bilabiate, tubular-funnelform, 10–16 mm, prominently 2-ridged within on abaxial surface, pale lavender (adaxial surface of lobes nearly white) or sometimes nearly white with prominent (sometimes faint) purple guide lines, especially on the abaxial surface of the corolla throat and on the adaxial surface of corolla lobes, pubescent externally with glandular-capitate hairs; tube 6–7 mm, throat 5–7 mm long, open, abruptly expanded from the tube, lobes 5, 4–5 mm, abaxial lobes 3, spreading and declined, projecting beyond the adaxial lobes, adaxial lobes 2, slightly shorter than the abaxial ones, upwardly curved to erect. **Stamens** 4, included in throat, filaments strongly curving, 10–12 mm, anthers very finely papillose, the 2 locules strongly divergent, each 0.8 mm × 0.5 mm. **Staminode** 7–8 mm, reaching the orifice and slightly exserted, densely bearded in distal 4–5 mm, beard golden-brown, beard hairs 1–1.2 mm. **Capsules** broadly ovoid, narrowly rounded at apex, 5–6 mm × 3.5–4 mm. Seeds ca. 1 mm (not seen at full maturity). **Chromosome number** unknown.

Additional specimens examined: **UNITED STATES. ALABAMA. Blount Co.:** banks of small calcareous branch near NW base of Warnock [*sic*, *recte* Wornock] Mountain, 4 May 1938, *R. Harper 3658* (MO); 2.25 air mi. NW of Brooksville, area just N of Curtis Williams Lake, E of US Hwy 231, 30 Apr 2011, *B.R. Keener 6430 with T. Keener & W.K. Webb* (UWAL). **Jackson Co.:** 0.4 of a mi E on US 72 from its jct. with Jackson County Road 63, 19 May 1990, *S. & G. Jones 4880* (VDB). **Madison Co.:** mountain region, Huntsville, 29 May 1896, *L.M. Underwood s.n.* (ALU); along brook at dead end of Ridgeview Circle in SE Huntsville, 3 May 1964, *A. Aller 42* (VDB); open woods on a hill off Highway 231 in vicinity of Mt. Charon, May 1973, *P. Benson s.n. with K. Gentle & P. Weeks* (UNA); rich woods along Mountain Fork Creek outside New Market, 9 Jun 1997, *S.J. Threlkeld 1044 with J.F. Duke* (JSU). **Morgan Co.:** edge of mesic woods above cutoff of Flint Creek, 1.2 mi S [of] Lacon, 29 May 1970, *R. Kral 39341* (MO, VDB); Newsome's Sinks 1.0 mi W of Morgan City, 24 May 1980, *R.A. Meigs 625* (UNA). **TENNESSEE. Franklin Co.:** 6 km SE of Huntland, lower S slope of Cedar Ridge near junction of Arkansas Hollow and Opossum Hollow, along N side of Arkansas Hollow Road, edge of dry oak-hickory forest over Mississippian limestone, 35.005382°N, -86.235979° W, 4 May 2011, *D. Estes 11,901 with D. York & C. Gorman* (APSC, TENN); 4.3 km SSE of Cowan, S end of Keith Cove, along jeep trail on lower NE facing slope above Keith Cove Road, edge of oak-hickory forest over Mississippian limestone, 35.126885° N, -86.000705° W, 25 May 2011, *D. Estes 11,902 with D. York, C. Gorman, M. Bruton, R. Shepard et al.* (APSC, TENN, NCU).

Etymology.—The epithet "*kralii*" was chosen to honor Dr. Robert Kral (1926–), one of the top 20th-Century American plant taxonomists. Dr. Kral is Professor Emeritus of Vanderbilt University, curator of the VDB herbarium and research associate at the Botanical Research Institute of Texas in Ft. Worth. He has arguably been one of the most significant contributors to the flora of the eastern United States and is widely renowned for his knowledge of the flora of the southeastern U.S. Dr. Kral's professional accomplishments are extraordinary. During his 52-year career he has collected nearly 100,000 specimen numbers, not to mention hundreds of thousands of duplicates that have been widely disseminated to dozens of herbaria. Additionally, he has named more than 100 new species, including new taxa from both North and South America. He has tackled many difficult taxonomic problems in eastern North American botany and his work has clarified such difficult genera as *Carex*, *Eriocaulon*, *Fimbristylis*, *Rhynchospora*, and *Xyris*. Although not widely circulated, Dr. Kral's two-volume, 1,305-paged U.S. Forest Service report, "*A Report on Some Rare, Threatened, or Endangered Forest-Related Vascular Plants of the South*" remains perhaps the most important single contribution to our understanding of rare and narrowly endemic plants of the southeastern U.S. since J.K. Small published his *Manual of the Southeastern Flora* in 1933. Dr. Kral continues to publish and work on taxonomic treatments, especially of New World Xyridaceae, and *The Flora of Alabama and Middle Tennessee*. Given Dr. Kral's exceptional taxonomic eye and the fact that he has collected plants all over the Southeast, it is no surprise that he collected this new *Penstemon* from Morgan County, Alabama in 1970. I have always admired and been inspired by Dr. Kral's accomplishments and quality of work and it is my pleasure to name this new species in his honor.

Common Name.—Kral's Beardtongue

Distribution and Ecology.—*Penstemon kralii* is endemic to the lower slopes of the southwestern Cumberland Plateau escarpment of northeastern Alabama and southeastern middle Tennessee (Fig. 3). It is found at the edges of calcareous juniper-oak-hickory woodlands over Mississippian-aged limestone at elevations ranging from 198–335 m (650–1,100 ft) above sea level. Tree species characteristically found with *P. kralii* include *Quercus muehlenbergii* Engelm., *Q. shumardii* Buckley, *Carya carolinae-septentrionalis* (Ashe) Engl. & Graebn., *Fraxinus americana* L., *Juniperus virginiana* L., *Ulmus alata* Michx., and *Cotinus obovatus* Raf. Small tree and shrub species include *Cercis canadensis* L., *Viburnum rufidulum* Raf., *Sideroxylon lycioides* L., *Hypericum frondosum* Michx., and *Forestiera ligustrina* (Michx.) Poir. Herbaceous species at these sites include *Camassia scilloides* (Raf.) Cory, *Clematis glaucophylla* Small, *Helianthus microcephalus* Torr. & A. Gray, *Polymnia canadensis* L., *Silphium brachiatum* Gatt., *Sisyrinchium* sp. nov., *Solidago auriculata* Shuttlew. ex S.F. Blake, *Spigelia marilandica* (L.) L., *Verbesina virginica* L., and *Vernonia flaccidifolia* Small.

Conservation Status.—*Penstemon kralii* is known only from a few sites in five counties of Alabama and Tennessee. The paucity of collections in herbaria gives some indication as to its rarity. Judging from the absence of herbarium specimens, *P. kralii* apparently has not been collected from Tennessee prior to this study. This is intriguing given the abundance of fieldwork that has been conducted in southern Franklin County. Although more extensive surveys will almost certainly result in the discovery of additional populations it is likely that this species is truly rare and deserving of protection at the state level.

Collection History.—The earliest collection found for *P. kralii* dates to 1896 from near Huntsville, Alabama. In 1938, Roland Harper collected it in Blount County, Alabama. His typed label originally did not give a specific epithet for the collection. Sometime after the original label was made, the inscription "laevigatus?" was added in pencil, though it is not clear whether this was by Harper or someone else. In 1970, Robert Kral collected this species from Morgan County, Alabama, and identified his specimen as "*P. laevigatus*?". From Kral's inclusion of the question mark, it is clear that he was not satisfied with his determination. Between 1964 and 1997, the species was collected several times by various botanists, adding additional collections from nearby Jackson and Madison counties in Alabama. The first collections of this species from Tennessee were made in May 2011 during this study. A review of specimens at TENN, UOS, UCHT, APSC, and VDB failed to reveal any prior collections from Tennessee.

Comparison with Similar Species.—In the herbarium *Penstemon kralii* resembles *P. laevigatus* Ait., *P. tenuis*, and *P. smallii*. *Penstemon laevigatus* is considered to be closely allied to *P. calycosus* Small and *P. digitalis* Nutt. ex Sims (Pennell 1935). *Penstemon laevigatus* shares the following characteristics with *P. digitalis* and *P. calycosus*: (1) leaves generally entire to remotely toothed; (2) stems, below the inflorescences, eglandular-puberulent with very short trichomes either arranged in lines or essentially lacking, usually not consistently covering the stems; (3) corolla tubes conspicuously and greatly dilated into the much expanded throats; (4) interior ventral surfaces of the corolla throats flat and not distinctly 2-ridged. In contrast *P. kralii* differs in having (1) leaves that are consistently closely and sharply serrate; (2) stems that are closely and consistently eglandular-puberulent throughout; (3) corolla tubes that are slightly expanded and lack conspicuously dilated throats; and (4) interior abaxial surfaces of the corolla throats distinctly and prominently 2-ridged. It should be noted that corolla tube dilation is relative. *Penstemon kralii* has tubes that are dilated compared to other *Penstemon* species (e.g., P. *tenuiflorus* Pennell), but they are not nearly as dilated as in *P. calycosus*, *P. digitalis*, and *P. laevigatus*.

The combination of features described above for *P. kralii* is also found in *P. smallii* and *P. tenuis*. None of these species overlaps in distribution with *P. kralii*. From *P. tenuis*, *P. kralii* differs in its wider leaves, paler corollas (lavender to whitish with conspicuous dark purple veins vs. darker lavender, purple, or pink and inconspicuously-lined in *P. tenuis*), and less-dilated corolla throats. *Penstemon kralii* also grows in a very different habitat compared to *P. tenuis*. It is an upland plant of dry to submesic or rarely rich soil in edge habitats or along streams over limestone on mountainsides. In contrast, *P. tenuis* is a wetland plant that grows in bottomland hardwood forests, seasonally wet flatwoods, wet ditches, and wet prairies. *Penstemon kralii* and *P. tenuis* also occur in two different regions. *Penstemon kralii* is endemic to the southern Cumberland Plateau escarpment of Alabama and Tennessee; *P. tenuis* is found from coastal east Texas east to southeastern Louisiana north to southeastern Missouri where it is found mostly in the floodplain of the Mississippi River and its major tributaries. *Penstemon kralii* is separated 300 km from the nearest populations of *P. tenuis* in the Mississippi Alluvial Plain of west-central Mississippi. Small's (1903) report of *P. tenuis* from Alabama may be based on *P. kralii*.

Based on morphology, *P. kralii* and *P. tenuis* seem to form a natural group with *P. smallii*. *Penstemon smallii* is readily differentiated from smaller-flowered *P. kralii* and *P. tenuis* (corollas of both 10–16 mm) by its much larger corollas (28–35 mm long). The corollas of *P. smallii* are dark pinkish or purplish and more closely resemble the pinkish or purplish corollas of *P. tenuis* than the very pale lavender to nearly white corollas of *P. kralii*. It also has generally larger leaves. In terms of habitat *P. smallii* and *P. kralii* are somewhat similar. Both occur in upland, dissected, and generally mountainous terrain, and both often grow in edge habitats. *Penstemon smallii* typically occurs in moister habitats than *P. kralii* and is rarely associated with limestone-derived

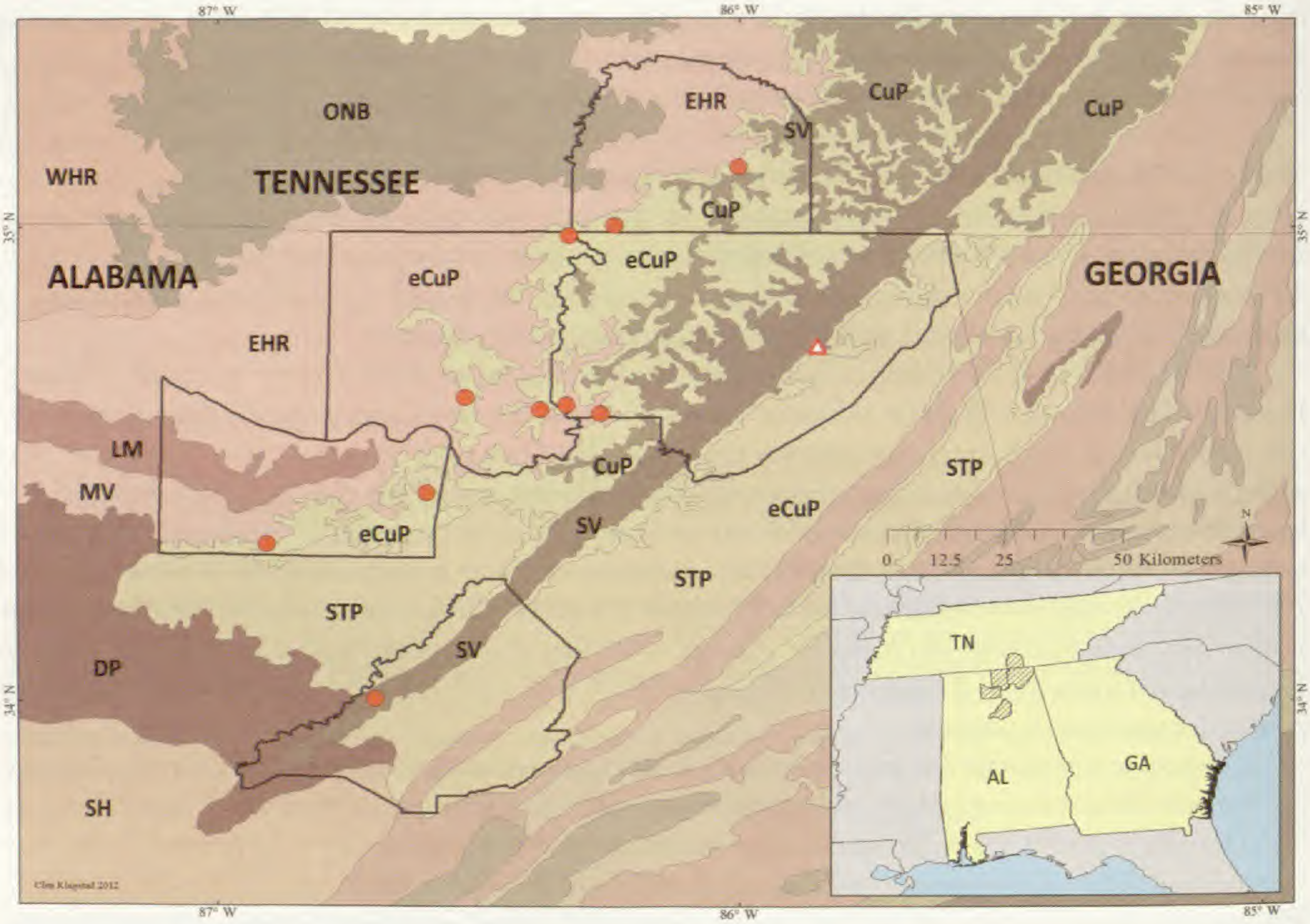


Fig. 3. Distribution of *Penstemon kralii* (circles). The triangle represents a fruiting specimen (Gunn & Bailey 2008, VDB) that is either *P. kralii* or *P. smallii*; its specific identity cannot be determined at this time without flowers. Physiographic designations primarily follow Griffith et al. (2001). CuP = Cumberland Plateau; eCuP = Cumberland Plateau Escarpment; DP = Dissected Plateau; EHR = Eastern Highland Rim; LM = Little Mountain; MV = Moulton Valley; ONB = Outer Nashville Basin; SH = Shale Hills; STP = Southern Table Plateaus; SV = Sequatchie Valley; WHR = Western Highland Rim.

soils. *Penstemon smallii* is a Southern Appalachian endemic found in the Blue Ridge Mountains and adjacent Ridge and Valley province. It is known from western North Carolina, eastern Tennessee, northern Georgia, and northwestern South Carolina. The southwestern-most occurrence of *P. smallii* is from banks of the Tennessee River near Chattanooga, Hamilton County, Tennessee, ca. 95 km NE of the nearest *P. kralii* population in Jackson County, Alabama. In the course of this study, all records of *P. smallii* from Tennessee and Alabama were carefully checked for accuracy. Previous Alabama reports from Clay and Pike counties proved to be based on misidentifications of *Penstemon australis* Small (C. Hansen, Auburn University, pers. comm. & A.R. Diamond, Troy University, pers. comm.). Two additional specimens from northeastern Alabama were found that were identified as *P. smallii*. One of these, a collection from Madison County (*Threlkeld & Duke 1044*, JSU), is actually *P. kralii*. The other is a fruiting collection from bluffs above the Tennessee River in eastern Jackson County (*Gunn & Bailey 2008*, VDB). This population is located 44 km E of the nearest *P. kralii* population in extreme western Jackson County and 55 km SW of the nearest occurrence of *P. smallii* in Hamilton County, Tennessee (also on a bluff of the Tennessee River). Because this specimen is in fruiting condition, it cannot be positively determined whether it is *P. kralii* or *P. smallii*. A visit to this population during flowering will be necessary to make a correct identification. If it is *P. kralii*, then it would be the easternmost population. If it is *P. smallii*, then it would be the southwesternmost occurrence for what is primarily a Blue Ridge species and Alabama's only population.

UPDATED KEY TO *PENSTEMON* OF THE SOUTHEASTERN* UNITED STATES

1. Cauline leaves deeply pinnatifid to bipinnatifid ____ **P. dissectus** Ell.
1. Cauline leaves entire or toothed.

2. Leaves connate-perfoliate, glaucous; corollas scarlet **P. murrayanus** Hook.
2. Leaves sessile, not glaucous; corollas white, pink, lavender, or purplish.
  3. Corollas 35–55 mm; capsules 13–18 mm × 8–10 mm.
    4. Corollas white to pink **P. cobaea** Nutt. var. **cobaea**
    4. Corollas violet to purple **P. cobaea** Nutt. var. **purpureus** Pennell
  3. Corollas 12–35 mm; capsules 7–14 mm × 3–6 mm.
    5. Anther sacs only partially dehiscing, the distal halves or two-thirds remaining indehiscent **P. multiflorus** Chapm. ex Benth.
    5. Anther sacs dehiscing completely from connectives to tips.
      6. Corollas weakly bilabiate, white, unlined, tubes glandular-puberulent internally, gradually dilated into the throats; stems glabrous; cauline leaves abruptly reduced distally **P. tubaeflorus** Nutt.
      6. Corollas distinctly bilabiate, variously colored, lined (except *P. hirsutus*, *P. tenuiflorus* and *P. oklahomensis*); corolla tubes glabrous or eglandular-pubescent internally, abruptly or gradually dilated into the throats; stems pubescent throughout, pubescent in lines or patches, or glabrous; cauline leaves gradually reduced distally or not notably reduced.
        7. Abaxial and adaxial corolla lobes about equal in size, corollas not strongly 2-ridged on the abaxial surface within, corolla tubes conspicuously dilated into the throats; stems (proximal to inflorescences—check midstem) glabrous or puberulent with short, eglandular hairs distributed in patches or lines and not covering entire stem surfaces (*Penstemon digitalis* Complex).
          8. Corollas 20–35 mm long.
            9. Corollas white with purple lines; sepals ovate to ovate-lanceolate, acuminate into apex, 4.5–6.5 mm at anthesis; anthers with several to many hairs **P. digitalis** Nutt. ex Sims
            9. Corollas purplish to lavender; sepals linear-lanceolate, straight-attenuate into apex, 5–9 mm at anthesis; anthers finely glabrous to papillose **P. calycosus** Small
          8. Corollas 15–23 mm long.
            10. Sepals 1.5–3.5(–4) mm; corollas white **P. deamii** Pennell
            10. Sepals 3–6 mm; corollas tinged with lavender or white.
              11. Leaves mostly 1.5–2.5 cm wide; anthers glabrous or papillose **P. laevigatus** Ait.
              11. Leaves mostly 2.5–4 cm wide; anthers bearded or with long papillae **P. alluviorum** Pennell
        7. Abaxial corolla lobes exceeding adaxial lobes, corollas strongly 2-ridged on the abaxial surface within, corolla tubes slightly to moderately dilated into the throats; stems (proximal to inflorescences—check midstem) pubescent throughout, the hairs either with a mix of longer glandular and shorter eglandular hairs or with only short, eglandular hairs.
          12. Stems (proximal to inflorescences—check midstem) with a mix of longer glandular and shorter eglandular hairs.
            13. Corolla throats closed or nearly so (abaxial lips arching upward pressing against the adaxial lips); corollas unlined or very obscurely lined (except *P. australis*).
              14. Corollas lined; inflorescence branches stiffly erect, nearly paralleling the inflorescence axes **P. australis** Small
              14. Corollas unlined; inflorescence branches spreading-ascending, diverging from inflorescence axes (*Penstemon hirsutus* Complex).
                15. Corollas tinged with purplish-violet, lobes often white; leaves sparsely pubescent to glabrate (at least between veins) **P. hirsutus** (L.) Willd.
                15. Corollas creamy-white to ochroleucous throughout; leaves moderately to densely pubescent or puberulent.
                  16. Leaves moderately to densely glandular pubescent; plants of AL, TN, and KY **P. tenuiflorus** Pennell
                  16 Leaves puberulent; plants of OK and TX **P. oklahomensis** Pennell
            13. Corolla throats open (abaxial lips not arching up against the adaxial lips, except sometimes nearly closed in *P. australis*); corollas lined (at least internally) (*Penstemon canescens* Complex).
              17. Corollas 14–23 mm.
                18. Sepals 2–3.5 mm, 1–1.5 times longer than wide; corollas pale lavender (sometimes appearing nearly white, especially on herbarium specimens) **P. brevisepalus** Pennell
                18. Sepals 3–5 mm, 1.5–2.5 times longer than wide; corollas creamy white with violet lines **P. pallidus** Small
              17. Corollas 20–32 mm.
                19. Corollas 20–25 mm; sepals 4–5.2 mm; inflorescence branches stiffly erect, nearly paralleling the inflorescence axes **P. australis** Small
                19. Corolla 20–30 mm; sepals 3.2–4.5 mm; inflorescence branches spreading-ascending, diverging from inflorescence axes **P. canescens** (Britt.) Britt.
          12. Stems (proximal to inflorescences—check midstem) with only short, eglandular hairs (rarely with a few glandular in *P. smallii*).
            20. Leaves linear-lanceolate, 4–5 times longer than wide, 4–28 mm wide.
              21. Corollas 20–35 mm; leaves usually dilated at base; capsules 8–10 mm × 6–7 mm **P. laxiflorus** Pennell
              21. Corollas 10–20 mm; leaves not conspicuously dilated at base; capsules 4–7 mm × 4–5 mm **P. arkansanus** Pennell

20. Leaves ovate-lanceolate to lanceolate, 2.5–4 times longer than wide, 15–60 mm wide (*Penstemon smallii* Complex).
    22. Corollas 28–35 mm, lavender, violet, or purple; staminodes 15–18 mm, densely bearded in the distal 13–15 mm; largest leaf blades mostly 30–60 mm wide __________ **P. smallii** Heller
    22. Corollas 10–16 mm; staminodes 7–9 mm, densely bearded in the distal 4–5 mm; largest leaf blades mostly 10–40 mm wide.
        23. Leaves mostly 10–30 mm wide; corolla lavender, pink, or violet, inconspicuously-lined with reddish-purple lines, sepals ovate-lanceolate; plants of wetlands __________ **P. tenuis** Small
        23. Leaves mostly 30–40 mm wide; corolla pale-lavender to whitish, usually strongly lined with dark violet lines, sepals linear-attenuate; plants of dry or mesic calcareous uplands __________ **P. kralii** D. Estes

**Penstemon fendleri* Torr. & A. Gray, *P. grandiflorus* Nutt., and *P. triflorus* A. Heller occur along the extreme western portion of what some consider the Southeastern U.S. in central Texas. These species have ranges that occur primarily west of the Eastern Deciduous Forest region and are excluded from the above key. Measurements in the key and text refer to length unless specified otherwise.

ACKNOWLEDGMENTS

I thank the Austin Peay State University Center of Excellence for Field Biology and the Department of Biology for travel support and release time for research. My graduate student, Clea Klagstad, kindly prepared the distribution map. Aaron Floden (TENN) and Wes Knapp (Maryland Department of Natural Resources) and my graduate students, Dawn York and Courtney Gorman (APSC), assisted with fieldwork. I greatly appreciate the feedback provided by Wayne Chester (APSC), Craig Freeman (KANU), Noel Holmgren (NY), and Theo Witsell (ANHC) who reviewed the manuscript prior to submission. Lastly, I especially thank Brian R. Keener (UWAL) and Andrea D. Wolfe (OS) for helpful review comments.

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A NEW SPECIES OF *FRAGARIA* (ROSACEAE) FROM OREGON

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ABSTRACT

Fragaria cascadensis K.E. Hummer, sp. nov. is endemic to the western high Cascade Mountain Range in Oregon, United States. This decaploid species can be distinguished by adaxial leaf hairs, distal tooth of the terminal leaflet always smaller than adjacent teeth, and comma-shaped achenes. Its known range is in the western Cascade Mountains from the Columbia River in the north, to the vicinity of Crater Lake in the south, at elevations of 1,000 to 3,800 m, in sandy-clay loams of volcanic origin, in forest clearings and open meadows.

RESUMEN

Fragaria cascadensis K.E. Hummer, sp. nov. es endémica de la Cordillera de las Cascadas en Oregón, Estados Unidos. Esta especie decaploide puede diferenciarse por los pelos del envés de las hojas, diente distal del foliolo terminal siempre más pequeño que los dientes adyacentes, y los aquenios en forma de coma. Su rango conocido va del oeste de la Cordillera de las Cascadas desde el río Columbia en el norte, a las proximidades del Crater Lake en el sur, a elevaciones de 1,000 a 3,800 m, en margas arenoso-calcáreas de origen volcánico, en claros de bosque y en parados abiertos.

DESCRIPTION

Fragaria cascadensis Hummer, sp. nov. (**Figs. 1–3**). Type: U.S.A. Oregon. Lane Co.: US NFDR 5897, southern exposure, disturbed area at forest edge, along roadside ditch, altitude 1433 m, with *Pseudotsuga menziesii*, 8 Aug 2011, *K.E. Hummer CFRA 2111* (holotype: OSC 233175).

Plants perennial, acaulescent, crown-forming herb with stolons and adventitious roots; petiole, pedicel, runner and calyx with dense, spreading hairs. **Stolons** red, sympodial. **Leaves** generally trifoliate, rarely quadri- or pentifoliate; slightly bluish green; adaxial surface with scattered appressed white hairs about 1 mm; not thick or coriaceous, and not reticulate-veiny beneath. Shape of leaflets variable, elongated to obovate, cuneiform or broadly round, truncate; margin variably serrate, entire to only upper third of leaflet; teeth small and pointed, rarely crenate, ciliate; distal tooth of the terminal leaflet always narrower and shorter than adjacent ones; accessory leaflets. **Inflorescence** compound dichasium with aborted epipodium including the terminal flower, of variable length, sub-to super foliar, 4 to 15 cm. **Flowers** subdiecious with plants growing in separate, or interspersed male, female, or hermaphrodite colonies; pistillate flowers 16.3(13.0–20.0) mm wide; staminate flowers 19.7(15.0–24.0). **Calyx** green rarely regular with 5 lanceolate sepals and 5 bractlets, frequently irregular, with 11 or 12 sub-equal parts. **Petals** white, usually 5 rarely 4 or 6, depressed obovate to very widely obovate, entire, emarginate, or unequally-bilobed, partially overlapping or not; **Stamens** about 0.5 mm long, protruding above sub-reflexed corolla; hermaphrodite flowers 23.1(17.0–30.0.) mm wide. **Pollen** grains about 34 µm air dried with longitudinal ridges (Type 1, Staudt 2009). **Pistils** light yellow, numerous, 1mm long, the group centrally located within the flower as attached to receptacle about 3(3–4) mm. **Receptacle in Fruit** shape variable from globose, subglobose, to ellipsoidal, and irregular; fruit set may be irregular, poor, or sometimes full, 1.0(0.5–1.2)cm wide × 1.5(1.0–1.75) cm long; fruit skin ripens red; fruit flesh white, juicy and sweetish, with flat to sour flavor. **Achenes** sometimes set in pits; length ~ 1.56 mm; ovary vasculature prominent on surface; lateral stylar edge frequently concave, forming a comma-shape. **Chromosome** number: $2n = 10x = 70$ (Nathewet et al. 2010; Hummer et al. 2011).

Differs from *F. chiloensis* and F. ×*ananassa* nothosp. *cuneifolia* by leaves not thick and coriaceous, not reticulate-veiny beneath. Differs from *F. vesca* subsp. *bracteata* by leaves usually slightly bluish green, and distal tooth of terminal leaflet always shorter than adjacent teeth as compared with leaves Kelly green and distal

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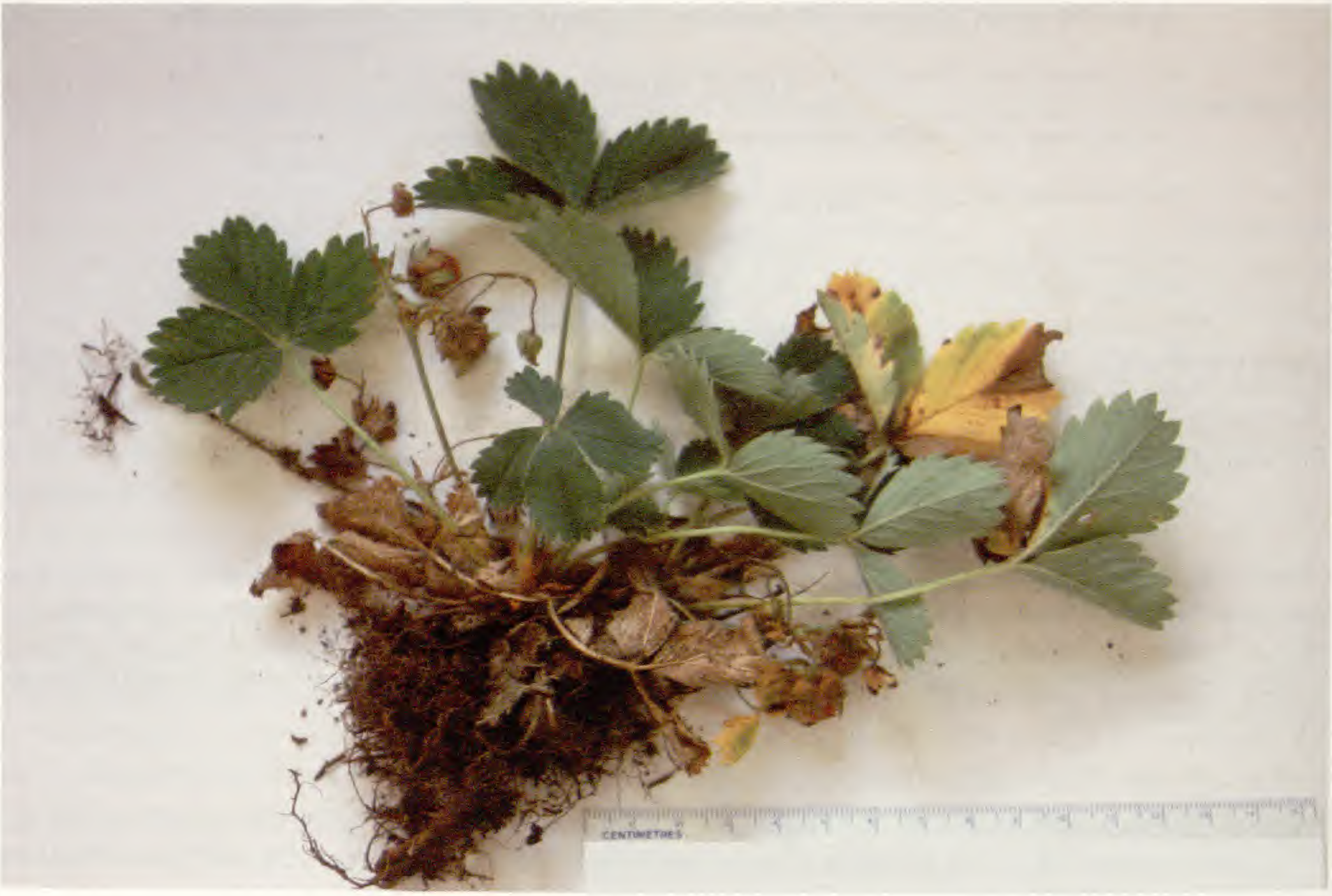

Fig. 1. ***Fragaria cascadensis*** **Hummer. Collected by *K.E. Hummer 2111* (OSC) (PI 664460) from USA, Oregon, Lane Co., NFBR 5897 near Waldo Lake, Oakridge vicinity. Southern exposure, disturbed area at forest edge, along roadside ditch, altitude 1433 m, 6 August 2011.**

tooth of terminal leaflet usually longer than adjacent teeth. Differs from *F. virginiana* subsp. *platypetala* by leaves with adaxial, scattered, appressed white hairs (~1 mm) and achenes frequently comma-shaped, lateral stylar edge concave as compared with adaxial leaf surface glaucous and achenes dome-shaped with straight lateral stylar edge. The distribution range is in the western Oregon Cascades at elevations from 1,000 to 3,800 m. Differs from all sympatric congeners by the decaploid chromosome number ($2n = 10x = 70$), whereas *F. vesca* subsp. *bracteata* is ($2n = 2x = 14$) and *F. virginiana* subsp. *platypetala* is ($2n = 8x = 56$).

Representative specimens: **U.S.A. OREGON. Deschutes Co.:** Carpenter Mountain, jct. Blue River and Lookout Trails, *J.F. Franklin 425* (OSC); Marshall Cabin, South Mount Hood, *L.F. Henderson 13831*(ORE); Pole Bridge, *O.L. Ireland 2481* (OSC); South Entrance, Crater Lake Park, *L. Wynd 2021*(OSC). **Hood River Co.:** Hood River, *H.S. Jackson s.n.* (OSC); McKenzie Pass, *L.F. Henderson 16829* (OSC). **Jefferson Co.:** Abbot Butte Spring Road, *K.C. Swedberg 79* (OSC). **Lane Co.:** US NFDR 5897 leading to Waldo Lake, *K. Hummer 2102* (OSC) *2104* (OSC) *2105* (OSC); US NFDR 5897 leading to Waldo Lake, *K. Hummer 2102* (OSC); US NFDR 5897 leading to Waldo Lake, *K. Hummer 2104* (OSC); US NFDR 5897 leading to Waldo Lake, *K. Hummer 2105* (OSC); 2 mi above Alder Springs Campground, McKenzie Hwy, *O.R. Ireland 592* (OSC). **Linn Co.:** Hoodoo Butte, *M.M. Thompson 95003* (OSC); Hoodoo Butte, *M.M. Thompson 95025* (OSC); Hoodoo Butte, *M.M. Thompson 95072* (OSC); Sandy Spring, McKenzie Pass Summit, *L.E. Detling 3242* (OSC); Santiam Highway, *M Cook s.n.* (OSC); Tombstone Prairie, *H.M. Gilkey s.n.* (OSC); Tombstone Pass, Iron Mountain, Cone Peak, Tombstone Prairie, *G. Staudt s.n.* (OSC); Tombstone Prairie, *H.M. Gilkey s.n.* (OSC); Tombstone Pass, Iron Mountain, Cone Peak, Tombstone Prairie, *H.L. Chambers 831113* (OSC).

Specimens maintained as living clones in greenhouses at USDA ARS NCGR: **U.S.A. OREGON. Clackamas Co.:** Mount Hood National Forest, Burnt Lake Trail, 45.35070, -121.80290, *PI 551794*; Mount Hood National Forest, Burnt Lake Trail, Clackamas Co., 45.35572, -121.79338, *CFRA 2061*. **Deschutes Co.:** Pacific Crest Trail, E of Big Lake, 44.34548, -121.86743, *PI 551518*. **Douglas Co.:** edge of Umpqua National Forest, western edge of Diamond Lake, 43.18259, -122.13815, *CFRA 2084*; edge of Umpqua National Forest, western edge of Diamond Lake, 43.18720, -122.15496, *CFRA 2085*; edge of Umpqua National Forest, western edge of Diamond Lake 43.18579, -122.15921 *CFRA 2086*; Rogue River National Forest, Oregon Rte. 62. 43.18579, -122.34467, *CFRA 2088*. **Klamath Co.:** Deschutes National Forest, Princess Creek Campground, Klamath Co., 43.58628, -122.00952, *CFRA 2068*. **Lane Co.:** Willamette National Forest, entrance road to Waldo Lake 43.61872, -121.82260, *CFRA 2065*; Willamette National Forest, entrance road to Waldo Lake, 43.61872, -122.07930, *CFRA 2066*; Willamette National Forest, Gold Lake Nordic Area Road entrance, 43.60542, -122.04697, *CFRA 2067*. **Linn Co.:** 4 mi S of Santiam Pass, E of

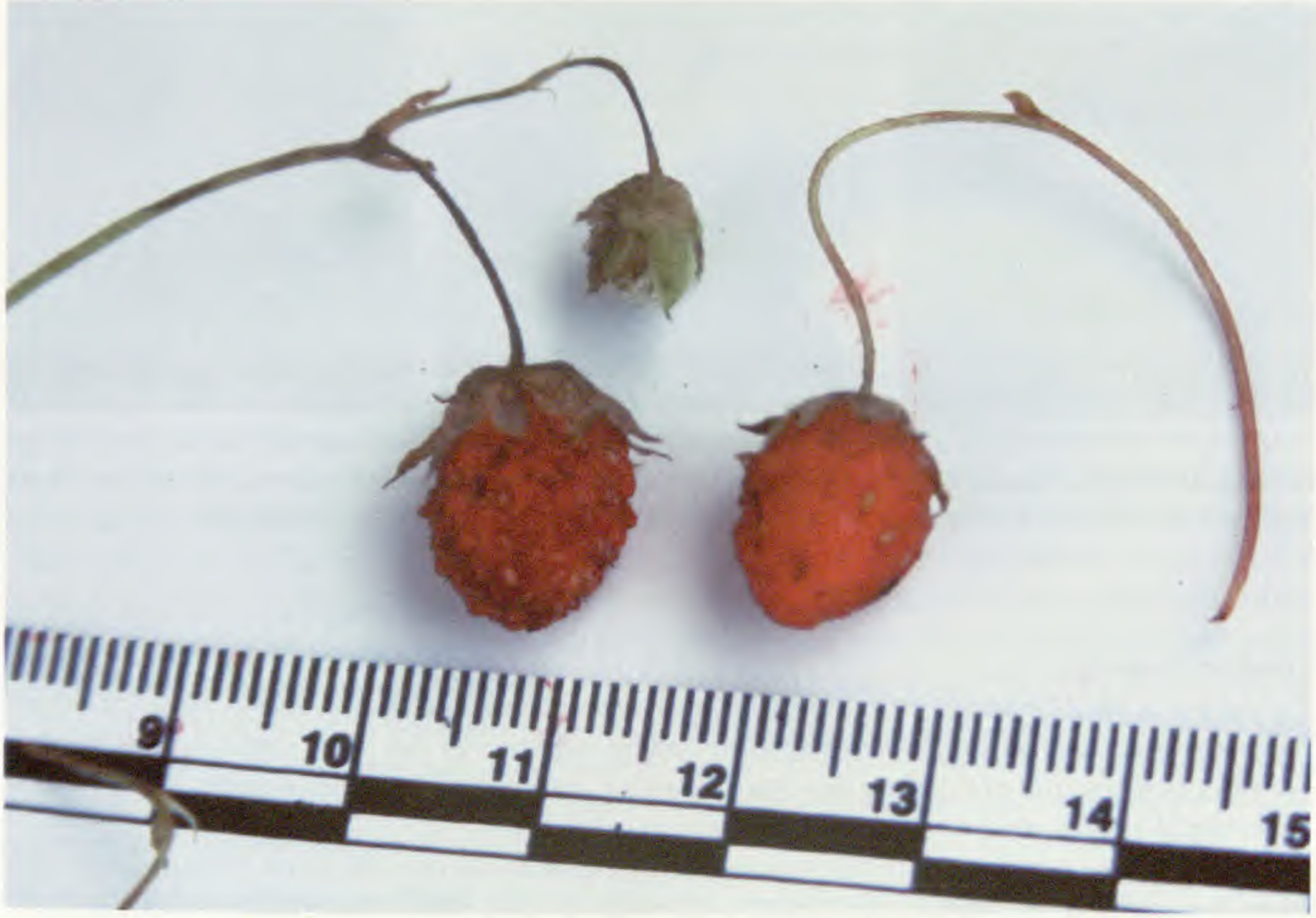

Fig. 2. Fruit of *Fragaria cascadensis* Hummer. collected by *K.E. Hummer 2111* (PI 664460) from USA, Oregon, Lane Co., Waldo Lake Entry Road, NFDR 5897, 6 Aug 2011.

Big Lake, 44.37065, -121.86562, *PI 551527*; E of Big Lake, Pacific Crest Trailhead, 44.37933, -122.08560, *PI 658460*; W of Big Lake, 44.37766, -121.87058, *PI 657862*; W of Big Lake, 45.37766, -121.87058, *PI 657865*; W of Big Lake, 44.37442, -121.87445, *PI 657863*; W of Big Lake, 45.41302, -122.087546, *PI 657867*.

Etymology.—This species is named for the Oregon Cascade Mountains.

Common name.—I suggest Cascade strawberry.

Distribution and habitat.—Populations of *Fragaria cascadensis* occur at elevations of 1,000 m to 3,800 m, to the west of the divide in the Oregon Cascade Mountains; from the Columbia River in the north, to the southern and western vicinity of Crater Lake in the south. This region is referred to as the "high peaks" (Alt & Hyndman 2009). Habitat: open alpine meadows, or on forest path edges, where direct sunlight breaks through the canopy; along stream banks or in roadside drainage ditches; growing in sandy-clay loam of volcanic origin. At these locations the dominant vegetation is usually Douglas fir [*Pseudotsuga menziesii* (Mirbel) Franco] or silver fir [*Abies amabilis* (Douglas ex Louden) Douglas ex Forbes]. Associated plants include: *Gaultheria humifusa* (Graham) Rydb., *Epilobium ciliatum* Raf., *Lupinus latifolius* J. Agardh., *Montia parvifolia* (Mociño ex de Candolle) Greene, *Vicia americana* Muhl. ex Willd., *Hieracium albiflorum* Hook., *Artemisia ludoviciana* Nutt., and *Agoseris grandiflora* (Nutt.) E. Greene. The soils have udic moisture and frigid soil temperature regimes. The mean annual precipitation in the northern part of the decaploid distribution range is 200 to 250 cm (Franklin & Dyrness 1973), but it is 100 cm or lower in the southern area.

Phenology.—*Fragaria cascadensis* begins growing after snowmelt in late May or early June, flowering in early July, about 2–3 weeks later than *F. virginiana* subsp. *platypetala* (Rydb.) Staudt at lower elevation below 1,000 m. Runner production begins after flowering. Fruit is ripe during August for about 2 weeks with plants at ≥ 1,500 m elevation ripening 1 to 2 weeks later than those at 1,000 m.

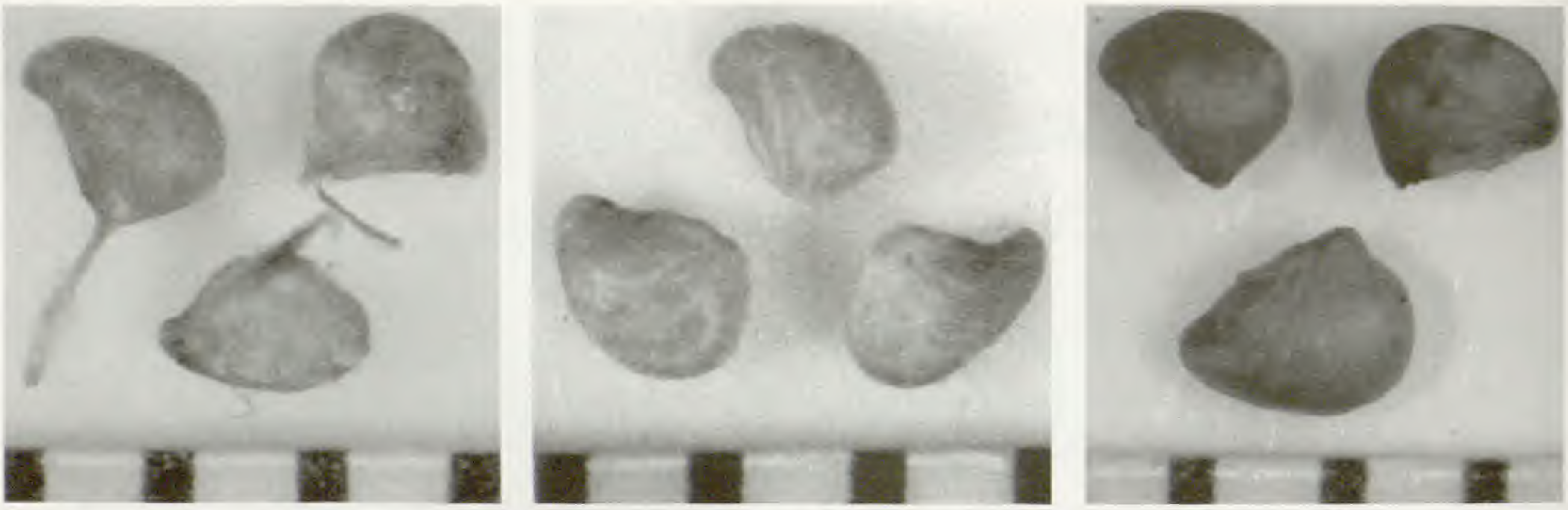

Fig. 3. Achenes of a) *Fragaria vesca* subsp. *bracteata* (PI 551813, CFRA 464, near Lost Lake, Oregon); b) *F. cascadensis* Hummer. (PI 664461, CFRA 2112, Big Lake Road, Oregon), and c) *F. virginiana* subsp. *platypetala*. (PI 551553, CFRA 176, near Prineville, Oregon). Bars represent 1 mm.

DISCUSSION

Congener Sympatry

Throughout much of Oregon, *F. virginiana* subsp. *platypetala* and *F. vesca* subsp. *bracteata* (A. Heller) Staudt are sympatric (Staudt 1999; Cook & Sundberg 2011). Sample collection for this study confirmed this frequent sympatry as well as that of *F. vesca* subsp. *bracteata* with *F. cascadensis* at locations near Mt. Hood, Hoodoo Butte, Iron Mountain, and Echo Mountain trail (Hummer et al. 2011).

From physical examination of native living plants at 17 locations from Mt. Hood through Crater Lake where *F. cascadensis* was present, no sympatric octoploids, or other plants of intermediate ploidy, as determined by flow cytometry, were observed (Hummer et al. 2012). However, three plants collected by L. Wynd (numbers 2020 for two plants and 2021 for one plant) in 1928, near the south entrance of Crater Lake, which were mounted together on a single herbarium sheet (OSC 46316), comprise two congeners: two plants with adaxial leaf surfaces that were glabrous and third plant with scattered leaf hairs (with hand written annotation by the collector on the hairs of that specimen). Although the collector originally determined that the pressed specimens on the sheet were one species despite the differential occurrence of the hairs, these specimens can now be re-interpreted as two *F. virginiana* subsp. *platypetala* plants and one of *F. cascadensis*, growing in sympatry near Crater Lake. The occurrence of diploid *F. vesca* subsp. *bracteata*, and octoploid *F. virginiana* subsp. *platypetala* in sympatry with each other and separately with decaploid *F. cascadensis* supports the idea that these taxa may have progenitor-descendant relationship.

Combination of morphological traits

Fragaria cascadensis has some morphological traits similar to those of *F. virginiana* subsp. *platypetala* and others more like those of *Fragaria vesca* subsp. *bracteata*. From several meters away, leaf and inflorescence morphology of the *F. cascadensis* is similar to that of *F. virginiana* subsp. *platypetala*, which is how this species escaped notice until recently. A defining difference is the presence of scattered appressed white hairs about 1 mm long on the adaxial leaf surface of *F. cascadensis*. This trait differs from the smooth, glabrous adaxial leaf surface of *F. virginiana* subsp. *platypetala*, but is similar to that of *F. vesca* subsp. *bracteata*, which has scattered to dense appressed, adaxial leaf surface hairs.

Another morphological difference separating *Fragaria cascadensis* from *F. virginiana* subsp. *platypetala* is achene shape. Some of the achenes of the Cascade strawberry are comma-shaped, having a concave lateral stylar edge, while those of *F. virginiana* subsp. *platypetala* are tear-drop shaped. The lengths of the achenes of *F. cascadensis* and *F. virginiana* subsp. *platypetala* are similar, 1.56–1.85 mm, and achenes of both species tend to be longer than those of *F. vesca* subsp. *bracteata*, which are about 1.37–1.56 mm long (Staudt 1999). Achenes of *F. vesca* subsp. *bracteata* frequently have a persistent style, while those of the other two taxa do not.

Inflorescence lengths of *Fragaria virginiana* subsp. *platypetala* are often short, usually shorter than the foliage. The inflorescence length in *F. cascadensis* is variable within a population, ranging from 4 to 15 cm and from shorter to taller than the foliage. That of *F. vesca* subsp. *bracteata* tends to be taller than the foliage.

1) Ploidy and Genetic Features

Decaploidy in *Fragaria cascadensis* was confirmed by chromosome counts and flow cytometry (Nathewet et al. 2010; Hummer et al. 2011, 2012). The Cascade strawberry has more alleles and more unique alleles (Njuguna 2010) than do octoploid strawberry species *F. virginiana* or *F. chiloensis*. A previous report of high genetic variation in *F. viriginiana* subsp. *platypetala* (Hokanson et al. 2006) partly resulted from the unknowing inclusion of three decaploid *F. cascadensis* samples (CFRA 101, CFRA 110, and CFRA 440) in that study.

Potential Progenitors

With a significant combination of morphological traits, *F. cascadensis* seems strongly linked to both *F. vesca* subsp. *bracteata* and *F. virginiana* subsp. *platypetala*. The facultative outcrossing of *F. vesca* subsp. *bracteata* and the findings of Dermen and Darrow (1938) and Njuguna et al. (2010) suggest that the direction of a hybridization event would likely be *F. vesca* subsp. *bracteata* (or a polyploid derivative) as the mother, and *F. virginiana* subsp. *platypetala* (or a derivative) as the pollen parent, if there was a direct cross. Reports summarized by Dermen and Darrow (1938) and Darrow (1966) indicated that autotetraploids arising from a diploid as mother, with the pollen of higher ploidy cytotypes, could produce a successful cross. The reciprocal cross (with pollen from autotetraploid *F. vesca*) was unsuccessful in the laboratory (Dermen & Darrow 1938). This is, however, counter to Bringhurst's (1990) discussion of the origin of the California *F. ×bringhurstii* Staudt pentaploids. These genotypes have arisen from natural crosses of *F. chiloensis* with autotetraploid *F. vesca* subsp. *californica* (Cham. & Schltdl.) Staudt (Bringhurst 1990; Staudt 1999). Future work comparing plastid single nucleotide polymorphisms between the putative parents and *F. cascadensis* could determine the maternal parent.

2) Previously unrecognized cytotype

This unusual cytotype was overlooked by many studying *Fragaria* taxonomy. Other than the decaploid chromosome number, *F. cascadensis* appears similar to the octoploid *F. virginiana* subsp. *platypetala* as described by Staudt (1999). Close inspection is needed to see the morphological differences of hairy adaxial leaf surfaces and comma-shaped achenes. Therefore, *F. cascadensis* has gone unnoticed. Darrow (1966) who collected strawberries and performed many ploidy experiments including synthetic development of multiple levels of polyploidy was unaware of wild *Fragaria* species with more than 56 chromosomes. Hancock et al. (2001) and Harrison et al. (1997) extensively studied octoploid *F. virginiana* Mill. and *F. chiloensis* Losinsk. from North America, including *F. v.* subsp. *platypetala* from the Western Cascade Range of Washington, where all individuals are octoploid. Hokanson et al. (2006) unknowingly included three decaploid cytotypes (CFRA 101, CFRA 110, and CFRA 440) in their analysis, but assumed them to be octoploid.

3) For the present study, 23 OSC herbarium specimens were determined to be *F. cascadensis*, judging from adaxial leaf surface hairs and western High Cascades localities of origin. An additional 16 were determined as *F. vesca* subsp. *bracteata*, judging from adaxial leaf surface hairs, inflorescence length, leaf dentation (size, location, and number per leaf) and collection locality. Strawberry specimens at the OSC herbarium were reviewed and annotated by Staudt. His (Staudt 1999) described the upper leaf surface of *F. virginiana* subsp. *platypetala* as "smooth" based on his studies of strawberries from the Pacific North Western North America. With the definition of *F. cascadensis* sp. nov., I suggest that "smooth and glabrous" is a more appropriate description for the adaxial leaf surface of *F. virginiana* subsp. *platypetala*.

IDENTIFICATION KEY FOR WILD *FRAGARIA* IN OREGON

1. Leaves thick to somewhat thick, coriacious, strongly to not strongly reticulate-veiny beneath, superior surface dark green to bluish green; achenes large to medium; plants coastal to inland.
  2. Leaves thick, coriacious, strongly reticulate-veiny beneath, superior leaf surface dark green; achenes large (mean = 1.76, range 1.43–2.04 mm long); plants coastal ____ **F. chiloensis**
    3. Petioles, peduncles, pedicels and runners with appressed-ascending hairs, occasionally macroscopically almost glabrate ____ subsp. **lucida**
    3. Petioles, peduncles, pedicels and runners with spreading, usually dense hairs ____ subsp. **pacifica**

2. Leaves somewhat thick, coriacious, not-strongly reticulate-veiny beneath sometimes bluish green to slightly glaucous; achenes medium (mean = 1.4, range 1.33–1.75 mm long); plants coastal to inland ________ **F. ×ananassa** nothosubsp. **cuneifolia** (Nutt. ex Howell) Staudt

1. Leaves not thick and coriacious, not reticulate-veiny beneath, superior surface bluish green; achenes smaller (~ 1.37–1.56 mm long); plants inland.

4. Leaves bright green; leaflets ovate or obovate to slightly rhomboidal; distal tooth of terminal leaflet usually longer than adjacent teeth; teeth ~ 38 or more per leaf; flowers ~ 20 mm in diameter; inflorescence usually above foliage; flowers perfect, sometimes gynodioecious; calyx generally regular with 5 larger sepals and 5 smaller bractlets, sometimes 11 or 12 merous; calyx mostly reflexed from ripe fruit; achenes ~ 1.37–1.60 mm long, frequently with persistent aristate style ________ **F. vesca** subsp. **bracteata**

4. Leaves green to bluish green; leaflet shape variable, elongated to obovate, cuneiform or broadly round, truncate; distal tooth of terminal leaflet usually shorter than adjacent teeth; usually teeth ~ 27 per leaf; flowers ~ 20–30 mm in diameter; inflorescence usually lower than foliage or variable length; plants sub-dioecious; calyx sometimes 10 mostly 11 or 12 merous with equal length lanceolate members; calyx clasping or mostly clasping ripe fruit; achenes ~ 1.56(1.28–1.85) mm or longer, style not persistent.

5. Adaxial leaf surface glabrous; achenes generally tear-drop shape, about 1.5 mm long; distribution in the Oregon Coast Range, in the Willamette Valley and on eastern side of the divide of the Oregon Cascades; elevations generally < 1,000 m; plant octoploid ($2n = 8x = 56$) ________ **F. virginiana** subsp. **platypetala**

5. Adaxial leaf surface with appressed scattered white hairs (~ 1 mm); achenes frequently comma-shaped with concave stylar edge, sometimes tear-drop shaped; distribution in western high Cascade Mountains in Oregon from Mt. Hood vicinity in the north to Crater Lake vicinity in the south; elevations of 1,000 m to 3,800 m; plant decaploid ($2n = 8x = 70$) ________ **F. cascadensis**

CONCLUSIONS

Fragaria cascadensis, sp. nov., the Cascade strawberry, occurs in the western Oregon High Cascade Mountains. *Fragaria cascadensis* is visually similar in plant, inflorescence, and most traits of leaf morphology to *F. virginiana* subsp. *platypetala* octoploids as described by Staudt (1999). However, the decaploids also share two key characters with *F. vesca* subsp. *bracteata*, including adaxial leaf hairs and predominantly comma-shaped achenes.

We provide a cautionary note to breeders who wish to enhance the octoploid strawberry gene pool from wild North American material. If decaploids are inadvertently used in breeding programs in lieu of octoploids, crosses are possible but the resulting enneaploid progeny would have reduced fertility. As an example, a lower fecundity was observed in second generation crosses from Staudt et al. (2009) of *F. iturupensis* (a species since shown to be decaploid) with *F.* × ananassa cultivars (octoploid). From additional scattered sampling of wild *F. virginiana* subspecies across North America (Hummer et al. 2011), decaploid zones, other than the one in the Oregon High Cascade Mountains, have not been detected. However, detailed collection and examination of ploidy is warranted where native diploids and octoploids are sympatric congeners.

Fragaria cascadensis presents the possibility for developing and breeding a new class of cultivated strawberries at the decaploid level. The wild Oregon decaploids, the Kurile decaploid, *F. iturupensis* (Hummer et al. 2009), and cultivars of the artificial species *F.* ×*vescana* (Bauer 1993) may be inter-fertile, because of their equivalent ploidy. Recently Japanese breeders reported on new synthetic decaploids that included genes from the aromatic diploid *F. nilgerrensis* Schltdl. ex J. Gay (M. Morishita, pers. comm. 2012).Crossing within the decaploids should produce fertile offspring. Perhaps new flavors or resistant genes could be available to consumers from cultivated decaploid strawberries.

This newly described taxon enforces the view of post-glacial polyploid evolution (Harrison et al. 1997; Hancock et al. 2004; Hokanson et al. 2006) in the North American strawberries—not only with continued gene flow between sympatric octoploids, but with the additional dimension of hybrid combinations between multiple ploidy levels, such as diploids with octoploids.

ACKNOWLEDGMENTS

The support for this project from USDA ARS CRIS 5358-21000-038-00D is gratefully acknowledged. The author thanks Kenton L. Chambers for comments on the diagnosis; Nahla Bassil and Wambui Njuguna for genomic information; Tom Davis, Aaron Liston, Jim Oliphant, for frank discussions of data interpretation; Sugae Wada for photographic assistance; and Tom Davis and Daniel Porter for helpful reviews.

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BOOK REVIEW

Nan K. Chase. 2010. **Eat Your Yard: Edible Trees, Shrubs, Vines, Herbs and Flowers for Your Landscape.** (ISBN 13: 978-1-4236-0384-9; ISBN 10: 1-4236-0384-2, pbk.). Gibbs Smith, P.O. Box 667, Layton, Utah 84041, U.S.A. (**Orders:** www.gibbs-smith.com, 800-835-4993). $19.99, color throughout, 160 pp., 7.5" × 9.75".

Growing up during WWII meant most of our vegetables came from my father's Victory Garden. Endive, mint and parsley were grown in our yard near the fig tree. *Stalking the Wild Asparagus,* by Euell Gibbons, was one of my favorite books back in the early 1970s. Later, when I had grandchildren, they learned what plants they *could* eat rather than the ones they *should not* eat. They tasted the thyme, rosemary, garlic chives, etc. Every August was kept free for "putting up" the peaches. The pantry and freezer were full of preserves, chutney and pies from our delicious freestone peach tree. When the peach tree died, it was replaced with a pomegranate, which has flowered but not yet produced fruit.

Eat Your Yard is right up my alley … planting for food and beauty. Ms. Chase has chapters on edible trees, fruits, nuts, herbs and flowers. She includes histories of various plants; growing tips (locations and soil and sun conditions); recipes for using the harvests; and information for freezing, canning, dehydrating, pressing and fermenting.

Beautiful photographs illustrate how the trees and plants can be used to beautify the landscape around your home. Ms. Chase's choice of trees and plants takes into consideration their year round attractiveness in your landscape.

—Ann Schrader, Volunteer,
Botanical Research Institute of Texas, 1700 University Dr., Fort Worth, Texas 76107-3400, U.S.A.

RANUNCULUS GLACIALIS SUBSP. *ALASKENSIS* SUBSP. NOV. (RANUNCULACEAE), A BERINGIAN RACE OF AN OTHERWISE ATLANTIC SPECIES

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ABSTRACT

Ranunculus glacialis subsp. **alaskensis** is described as a new Beringian subspecies of an otherwise amphi-Atlantic and European species.

Key Words: Alaska, *Ranunculus*

RESUMEN

Se describe **Ranunculus glacialis** subsp. **alaskensis** como una nueva subespecie Beringiana de una especie anfiatlántica y europea.

The Seward Peninsula of western Alaska provides the closest geographic connection between North America and Northeast Asia across the Bering Strait where the continents are separated by less than 100 km. It has been of biogeographic interest since the early work of Eric Hultén who, in his classic 1937 study, developed the concept Beringia as a periglacial refugium for plants, involving both Asia and America. A.E. Porsild, also a prominent figure for his extensive early fieldwork, provided floristic details and described several new species (1939) from western Alaska. Yurtzev (1972), Murray et al. 1994, and Ickert-Bond et al. (2009) have summarized the floristic patterns of the Beringian flora to highlight what is similar on both sides of the Bering Strait and what is very different.

Intensive floristic inventories of the region were initiated in the 1980s by Kelso (1983, 1989). These continued through collaborative U.S.–Russia teams organized by the Panarctic Flora Project and sponsored by the National Park Service Beringian program in 1992 and 1993. In 1996 and 1997, as part of rare plant surveys supported by the U.S. Geological Survey, remote areas were investigated with helicopter support. Field work has brought about the discovery of taxa new to the region, to North America, and three taxa new to science: *Primula anvilensis* (Kelso 1987), *Douglasia beringensis* (Kelso et al. 1994), and *Parrya nauruaq* (Al-Shehbaz et al. 2007).

A previously unknown *Ranunculus* was found at four localities, all in the Kigluaik Mountains (Fig. 1) on the central Seward Peninsula. Persistent white petals that become reddish in age and the persistent sepals with dark reddish-brown pubescence are features shared with the amphi-Beringian *R. camissonis* Schltdl. and the amphi-Atlantic *R. glacialis* L.

Löve and Löve (1956) and several subsequent authors assigned *R. glacialis* and *R. camissonis* to the genus *Beckwithia* Jeps. [Erythea 6:97 (1898)], together with the type species *Beckwithia andersonii* (A. Gray) Jeps. [*Ranunculus andersonii* A. Gray], an endemic of western U.S.A.: CA, OR, ID, NV, UT and AZ. Whittemore (1997) kept these three species within *Ranunculus* but assigned them to *Ranunculus* sect. *Crymodes* (A. Gray)

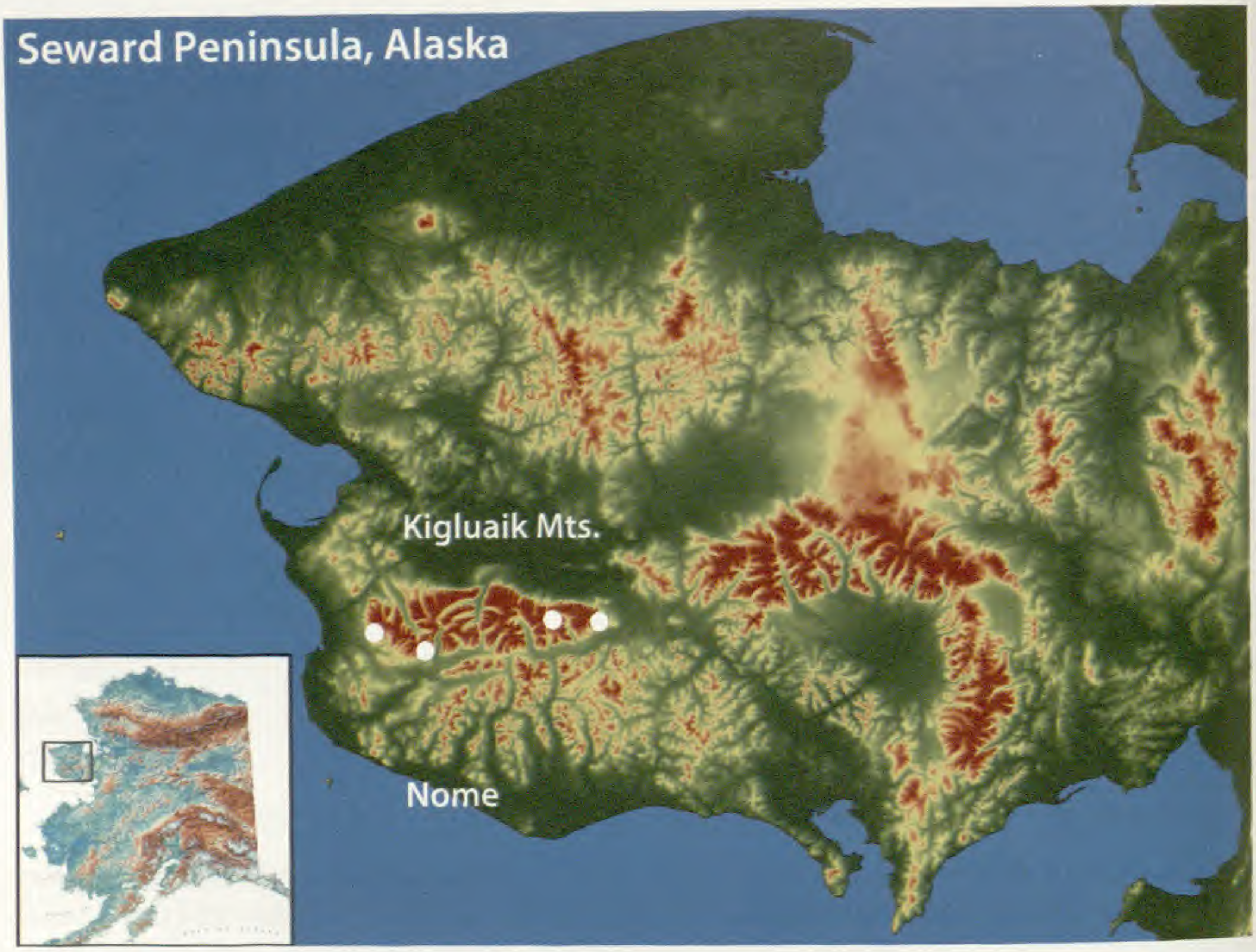

Fig. 1. Map showing distribution of *Ranunculus glacialis* subsp. *alaskensis*.

A. Gray, also based on *R. andersonii*. The morphological and molecular analyses of Hörandl et al. (2005), Paun et al. (2005), and Emadzade et al. (2010), using sequences of the *matK/trnK* and *psbJ-petA* regions, support *Beckwithia* as a genus apart from *Ranunculus*, but monotypic, consisting only of *B. andersonii*.

The two northern species of *Ranunculus—glacialis* and *camissonis*—have been allied with European species of sect. *Aconitifolii* Tutin containing the tall-grown and white-flowered *R. aconitifolius* L. and *R. platanifolius* L., which are confined to montane and subalpine tall-herb communities, and with *R. seguieri* Vill. and *R. kuepferi* Greuter & Burdet, alpine species of scree slopes and margins of snowbeds, respectively. The northern taxa, *R. glacialis* and *R. camissonis*, have a contrasting history, ecology, and distribution, but studies by Paun et al. (2005) show that the species of section *Aconitifolii* are phylogenetically coherent.

Ranunculus glacialis and *R. camissonis* have the following characteristics in common: Perennial plants with most leaves basal, long-petiolate, with blades deeply trisected or ternately divided (with more or less petiolulate leaflets in *R. glacialis*), main segments mostly dissected anew; flowering stems one to several with 2–4 leaves, similar to the basal ones or less divided, and with 1–3 (4) flowers; lower parts of the plant subglabrous or glabrous, upper parts with peduncles and sepals more or less densely pubescent with dark golden-brown hairs; petals 5–8, broadly obovate, white, becoming red-tinged and then purple after pollination. Both species are diploids with $2n = 16$. We recognize three taxa: two species, *R. camissonis* and *R. glacialis*, the latter with two infraspecific taxa subsp. *glacialis* and subsp. *alaskensis*. Subspecies *alaskensis* is new to science.

KEY TO THE TAXA

1. Stems mostly single, erect; blades of radical leaves deeply dissected into three oblanceolate to nearly linear main segments, often divided anew, with obliquely upward pointing subacute lobes, the two lateral main segments often smaller than the central one, blades cuneate at base; flowers single; sepals ovate; peduncles and sepals densely hairy ____ **R. camissonis**

1. Stems mostly several, ascending; blades of radical leaves ternately divided, main segments reniform in outline, subdivided into short, obtuse to rounded lobes, not upward pointing, the two lateral main segments nearly the same size as the central one, blades broadly cuneate to more or less truncate at base; flowers 1–3(–4); sepals obovate ____ **R. glacialis**
    2. Stems and peduncles glabrous (in the Alps with light, loosely appressed pubescence on peduncles); sepals with flexuose hairs up to 2 mm long, mostly appressed ____ subsp. **glacialis**
    2. Stems and especially peduncles with dense, long hairs; sepals with hairs 2–4 mm long, spreading to descending ____ subsp. **alaskensis**

Ranunculus glacialis L.

Beckwithia glacialis (L.) Á. Löve & D. Löve

In our concept, this is a European, amphi-Atlantic, and American Beringian species with two subspecies, the ranges of which are reported below. It is found in wet to damp gravelly or stony habitats, in open vegetation directly on mineral substrates without peat or other soil profiles, often in high alpine and arctic snowbank environments, on gravel bars along brooks and rivers, in periglacial environments including fresh morainal gravel and nunataks, and in wet or north-facing humid screes.

Ranunculus glacialis subsp. **glacialis**

The range is amphi-Atlantic. It is found in eastern Greenland, Jan Mayen, the southernmost part of Svalbard, Iceland, Fennoscandia eastwards to the Khibiny Mountains on the central Kola Peninsula (Russia), and in the major central European mountain ranges from the Pyrenees eastwards to the Carpathians. It reaches the altitudinal limit among vascular plants in Scandinavia (2370 m.s.m. Lid and Lid 2005) and is among those plants reaching the highest elevations in the Alps.

Ranunculus glacialis subsp. **alaskensis** Yurtzev, subsp. nov. (**Fig. 2**). TYPE: U.S.A. ALASKA: Seward Peninsula, Kigluaik Mountains, W of Glacial Lake, ca. 700 m.s.m., stony barrens and rubble screes, 11 Jul 1993, *D.F. Murray, B.A. Yurtzev, T. Kelso 11398* (HOLOTYPE: ALA; ISOTYPE: LE).

A forma typica caulibus in partibus superioribus et pedunculis atrorufae pubescentibus (nec glabris vel subglabris), sepalorum pilis saepius ad 4 mm longis, patentibus, rectis (non sepius subadpressis, brevioribus, flexuosis) differt. A *Ranunculus camissonis* foliis circumscriptione reniformibus (nec cuneatis), ternatis (foliolis petiolulatis), segmentis numerosibus, pro more obtusiusculis, latioribus brevioribusque (nec anguste lanceolatis, subacutis), caulibus ascendentibus vel rarius subprostratis (non suberectis vel erectis, gracilibusque) differt.

Habitat in peninsula Sewardensi Alaskae Occidentalis in montibus kigluaikensibus in decliviis et summatibus lapidosis glareosisque (non calcareis).

Subspecies *alaskensis* differs from subsp. *glacialis* by having in the upper parts of stem and peduncles dark brownish-red pubescence (not glabrous or subglabrous as in subsp *glacialis*), sepals with hairs up to 4 mm long, patent, erect to descending (vs hairs subappressed, shorter and flexuous). It differs from *R. camissonis* in its blades reniform in outline (not cuneate), ternately divided with petiolulate main segments, more numerous and more obtuse segments, the lateral ones shorter (not narrowly lanceolate and subacute), stems ascending or rarely prostrate (not suberect or erect), and sepals obovate (not ovate). See Figure 2.

This subspecies is known only from western Alaska: Seward Peninsula, four sites in the Kigluaik Mountains (Fig. 1) on rocky slopes of platy scree and on ridges and summits on non-calcareous substrates.

Ranunculus camissonis Schltdl.

Ranunculus glacialis subsp. *camissonis* (Schltdl.) Hultén; *Ranunculus glacialis* var. *camissonis* (Schltdl.) L.D. Benson; *Beckwithia camissonis* (Schltdl.) Tolm.; *Beckwithia glacialis* subsp. *camissonis* (Schltdl.) Á. Löve & D. Löve

This arctic, amphi-Beringian species reaches from the eastern Anyui mountains of northeastern Siberia and northwestern Russian Far East eastwards to western and northern Alaska with outliers in the alpine tundra of boreal mountains in the Interior (cf., Hultén 1968). It is found in moist to wet tundras, often on peat but mostly

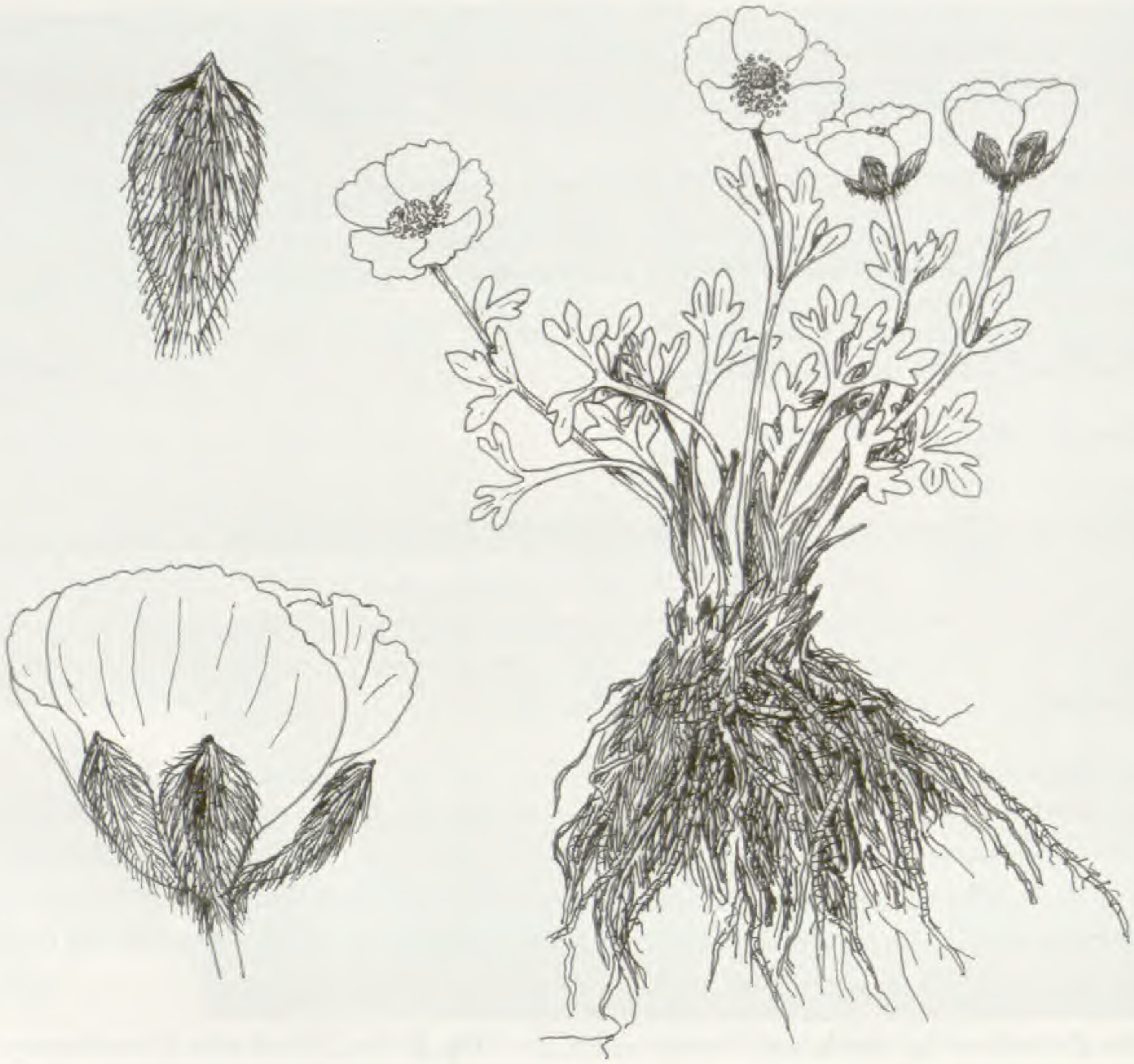

Fig. 2. ***Ranunculus glacialis*** **L. subsp.** ***alaskensis*** **Jurtzev, subsp. nov. Habit, flower, and sepal, based on ALA V114478. Alaska: Solomon Quad.: Seward Peninsula, Big Creek Valley, 23 Jul 1993,** ***D.F. Murray, B.A. Yurtzev & T. Kelso 11763*****. Illustration: Anne Elven.**

with underlying calcareous bedrock or morainal material, with a vegetation of forbs, sedges and mosses, often in seepages, in saddles (interfluves), along streams and temporary watercourses, and on moist, non-sorted soil circles ("frost boils"). The species has a preference for circumneutral substrates and avoids both dry limestone and very acidic sites.

Ranunculus camissonis differs from *R. glacialis* in several characters. No transitions have been observed in the material studied. Whether this is due to reproductive isolation or to their radically different habitats, making co-occurrence nearly impossible, is not known.

The range of *Ranunculus glacialis* subsp. *alaskensis* is within that of *R. camissonis*. Although the two are in a broad sense sympatric, due to the very different site requirements *R. glacialis* subsp. *alaskensis* is locally allopatric and has not yet been found at or even very close to a site of *R. camissonis*. The two plants are visually quite different, especially in growth shape and leaf shape, and are unlikely, in our view, to be mistaken for each other. Regrettably the illustration provided by Schlechtendal (1819) does not accurately portray the basal leaves of *R. camissonis*. See instead Figure 3 prepared for this paper.

The habitat of subsp. *alaskensis* is very similar to that of Atlantic *R. glacialis* s. str. and quite dissimilar to that of *R. camissonis*. The features it shares with *R. camissonis* are quantitative ones in the amount and length of pubescence and in petal proportions (see Figs. 2 and 3 for sepals). The constellation of characters separating subsp. *alaskensis* from *R. camissonis* and the lack of any transitions is sufficient to justify subsp. *alaskensis* as a taxon separate from *R. camissonis* and belonging to *R. glacialis*.

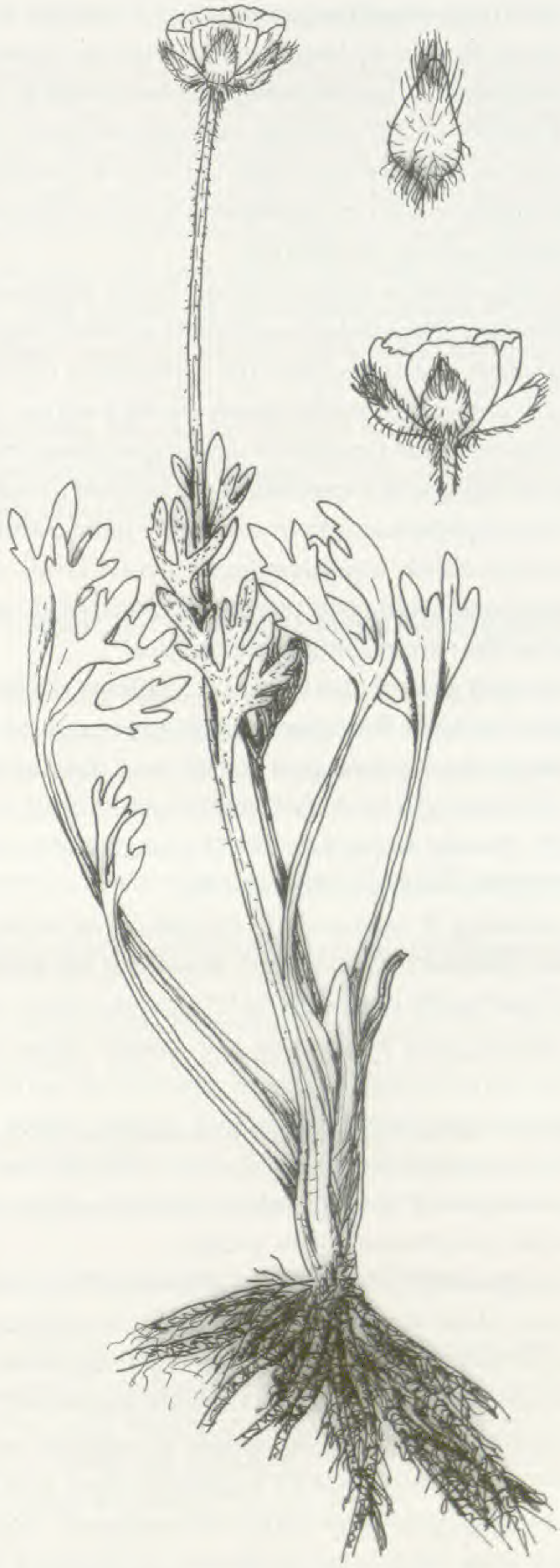

Fig. 3. ***Ranunculus camissonis*** **Schltdl. Habit, flower, and sepal, based on ALA V114333. Alaska: Bendeleben Quad.: Seward Peninsula, Minnie Creek headwaters, 16 Jul 1993,** ***D.F. Murray, B.A. Yurtzev & T. Kelso 11597*****. Illustration: Anne Elven.**

Differences between Atlantic and Beringian races of *R. glacialis* are to be expected from the large disjunction, either across the Polar Sea (more than 3000 km) or across nearly the entire continents with gaps of more than 130° longitude from eastern Greenland west to Alaska and more than 150° longitude from Alaska west to the Murman area in European Russia.

Schönswetter et al. (2003, 2004) postulated the persistence of *R. glacialis* in peripheral refugia of the Alps with post-glacial expansion to North Europe by long distance dispersal. However, the disjunctions and the discontinuous morphological variation in *R. glacialis* subsp. *alaskensis* and *R. camissonis* suggest origins well prior to the postglacial period of 10,000–15,000 years ago, although not nearly as early (Miocene) as proposed by Hoffmann et al. (2010). Whereas we agree with an origin in European mountains for *R. glacialis* subsp. *glacialis* or its precursor, we are still unable to offer an explanation for the Beringian *R. glacialis* subsp. *alaskensis* or for *R. camissonis*, which are wholly arctic in distribution.

The Beringian taxa suggest migrations or dispersal events from a European center across to Beringia either by an easterly or westerly direction. Dispersal across Eurasia or North America, without leaving remnant populations is not probable, although that is precisely the explanation offered for similar disjunctions in *Androsace*: dispersal of ancestors or of species from this genus during a warmer interval (interglacial) and subsequent persistence in the Beringian refugium throughout the last glacial maximum with the extirpation of the intervening populations during the full-glacial expansion of glaciers and ice-sheets (Schneeweiss et al. 2004). Fragmentation and significant loss of populations from a formerly more continuous, widely Eurasian or circumpolar range of *R. glacialis* seems unlikely to account for its present limits inasmuch as it has site requirements that are common, widespread, and presumably present continuously, during both glacial and interglacial intervals. How does one account for the remarkable geographic gaps?

A similar case of subspecies with gaps of distribution is *Saxifraga rivularis* subsp. *rivularis* and subsp. *arctolitoralis*, the former European, the latter Beringian with disjunct extensions to Greenland. The two subspecies are explained in this case as two separate, post-glacial, long-distance dispersal events from refugial centers established prior to the last major glaciation (Westergaard et al. 2010).

Any hypothesis as to how *R. glacialis* attained its disjunct range, and subsp. *alaskensis* its characters, is pure guesswork, and the former question may be unanswerable.

A phylogeographic study including *R. camissonis*, *R. glacialis* subsp. *alaskensis* and subsp. *glacialis*, employing plastid DNA and ITS data (Ronikier et al. in prep.), shows that the genetic divergence between *R. glacialis* subsp. *glacialis* on the one hand and *R. camissonis* and *R. glacialis* subsp. *alaskensis* on the other is much more shallow than the genetic split between populations of *R. glacialis* subsp. *glacialis* from the western and eastern Alps, indicating that dispersal to Beringia happened relatively late in the history of the complex. As the Beringian populations are phylogenetically deeply nested in *R. glacialis* subsp. *glacialis* and subsp. *alaskensis* and *R. camissonis* are not readily distinguishable genetically, they prefer to treat *R. camissonis* as subspecies of *R. glacialis* and are reluctant to recognise *R. glacialis* subsp. *alaskensis* as new taxon before better resolution with genetic data becomes available (Schönswetter pers. comm.).

We acknowledge the lack of agreement. Incongruence between phylogenetic and morphological studies of the same taxa are not uncommon. However, we see and by the key demonstrate that there are morphological discontinuities that distinguish the taxa. The fact remains that *R. glacialis* subsp. *alaskensis* has morphological features not found in subsp. *glacialis*. It is possible to discriminate consistently the two subspecies. It follows that the development of these features is under genetic control. It is obvious, too, that subsp. *alaskensis* is distinct from *R. camissonis* and more closely aligned with *R. glacialis*, albeit geographically distant from subsp. *glacialis*. We see no taxonomic value in making the three taxa equivalent. That *R. glacialis* and *R. camissonis* share genetic material is not surprising, but it is not inconsistent to present a taxonomy that emphasizes the sharply contrasting phenotypes and distinct ecological separation between *R. glacialis* subsp. *alaskensis* and *R. camissonis*.

Specimens examined of *Ranunculus glacialis* subsp. *alaskensis*. **U.S.A. ALASKA. Seward Peninsula:** Crete Creek, 64°53'N, 166°08'W, 229–381 m.s.m., 8 Jul 1993, *D.F. Murray, B.A. Yurtzev, T. Kelso 11313* (ALA, LE); do., 275 m.s.m., 2 Jul 1996, *D.F. Murray, R. Lipkin 12162* (ALA); Glacial Lake, Sinuk River valley, 64°52'N, 165°45'W, 702 m.s.m., 11 Jul 1993, *D.F. Murray, B.A. Yurtzev, T. Kelso 11398, holotype* (ALA); Big Creek valley, 64°59'N, 164°50'W, 23 Jul 1993, *D.F. Murray, B.A. Yurtzev, T. Kelso 11763* (ALA); Upper Fox Creek, 64°59'N, 165°03'W, 914 m.s.m., 5 Jul 1996, *D.F. Murray, R. Lipkin 12183* (ALA).

ACKNOWLEDGMENTS

Boris Alexandrovich Yurtzev presented us with the original manuscript prior to his death, which we have edited and expanded, but his views with respect to the new subspecies have been faithfully retained, and he alone is the author of the new subspecies. Sylvia Kelso was one of the field team with Yurtzev and Murray when the discovery of the new taxon was made, and we thank her for numerous helpful comments while preparing this manuscript. Our thanks to Anne Elven for the line drawings, to Zachary Meyers for the map, to Rob Lipkin for his work with us in the field 1996 and 1997. Dale Taylor, then with National Park Service, Anchorage, a strong supporter of Beringian studies, made possible the two summers of joint U.S.–Russia expeditions to the Seward Peninsula. Without his enthusiastic, hands-on support, these would not have been so successful. We are grateful to Peter Schönswetter for not only allowing us to see unpublished data on the molecular genetics of *Ranunculus glacialis* and *R. camissonis*, but also for carefully reviewing the manuscript, for summarizing the molecular results, and for suggesting important changes. Finally, our thanks to Alan R. Batten for his meticulous review of the manuscript for this journal.

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NEW COMBINATIONS FOR THE MONTANA FLORA

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ABSTRACT

Three new combinations are proposed. *Agoseris carnea* Rydb. and *A. lackschewitzii* Douglass M. Hend. & R.K. Moseley are considered the same entity and have been subsumed into *A. aurantiaca* (Hook.) Greene as a new infraspecific taxon. *Artemisia lindleyana* Besser has been treated as a distinct species, but a recent treatment subsumes it into *A. ludoviciana* Nutt. Similarities between the two entities are undeniable, but morphological and ecological differences lead me to believe that the former is best considered as a subspecies of the latter. Recent transfer of many New World asters into *Symphyotrichum* requires a new combination for *Aster cusickii* A. Gray if it is to be recognized as a subspecific taxon in *Symphyotrichum foliaceum* (Lindl. ex DC.) G.L. Nesom.

RESUMEN

Se proponen tres combinaciones nuevas. *Agoseris carnea* Rydb. y *A. lackschewitzii* Douglass M. Hend. & R.K. Moseley se consideran la misma entidad y se incluyen en *A. aurantiaca* (Hook.) Greene como un nuevo taxon infraespecífico. *Artemisia lindleyana* Besser ha sido tratada como una especie distinta, pero un tratamiento reciente la subsume en *A. ludoviciana* Nutt. Las semejanzas entre las dos entidades son innegables, pero las diferencias morfológicas y ecológicas me hacen creer que la primera está mejor considerada como una subespecie de la última. La reciente transferencia de muchas *Aster* del Nuevo Mundo a *Symphyotrichum* requieren una nueva combinación para *Aster cusickii* A. Gray si hay que reconocerla como un taxon subespecífico en *Symphyotrichum foliaceum* (Lindl. ex DC.) G.L. Nesom.

INTRODUCTION

Examination of herbarium material in preparation for a new floristic manual for Montana has convinced me that several new combinations are warranted.

SYSTEMATICS

Agoseris aurantiaca (Hook.) Greene var. **carnea** (Rydb.) P. Lesica, comb. nov. Basionym: *Agoseris carnea* Rydb., Mem. New York Bot. Gard. 1458. 1900. Type: CANADA. British Columbia: Mount Queest, 23 Jul 1889, *Macoun s.n.* (holotype: NY!).

Agoseris lackschewitzii Douglass M. Hend. & R.K. Moseley, Syst. Bot. 15:462–465. 1990.

Agoseris aurantiaca has traditionally been parsed into two varieties: var. *aurantiaca* has lanceolate phyllaries, ciliate and villous on the outer surface and achenes abruptly narrowed to the beak; var. *purpurea* (A. Gray) Cronquist has ovate-attenuate, outer phyllaries, ciliate but glabrous on the outer surface and achenes gradually tapered to the beak (Cronquist 1994; Baird 2006). *Agoseris carnea* Rydb. has traditionally been subsumed under *A. aurantiaca* var. *aurantiaca* because of its similar involucre (Hitchcock et al. 1955; Cronquist 1994; Baird 2006) although it has pink rather than orange rays in fresh material (Rydberg 1900). Henderson et al. (1990) described this pink-flowered *Agoseris* as *A. lackschewitzii* from material collected in east-central Idaho and adjacent Montana, U.S.A. and were unaware of the plant occurring in British Columbia, Canada, and having been previously described as *A. carnea* by Rydberg. However, they correctly pointed out that this pink-flowered form has narrow, villous phyllaries as in *A. aurantiaca* var. *aurantiaca* but achenes gradually tapered to the beak as in var. *purpurea*, and that it occurred in moist to wet meadows, an unusual habitat for either variety of *A. aurantiaca*. Though Henderson et al. (1990) believed these plants represented a distinct species, the close relationship to *A. aurantiaca* cannot be denied, and I believe it is better placed as a third variety of *A. aurantiaca* distinguished from the other two as follows:

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1. Outer phyllaries ovate abruptly narrowed to the attenuate tip, glabrous on the outer face ______ var. **purpurea**
1. Outer phyllaries narrowly lanceolate, evenly tapered to the tip and villous on the outer face.
    2. Rays pink at anthesis; achenes tapered to the beak ______ var. **carnea**
    2. Rays orange (sometimes drying pink); achenes abruptly tapered to the beak ______ var. **aurantiaca**

Agoseris aurantiaca var. *carnea* is found in upper montane to subalpine moist to wet meadows from British Columbia and Alberta south to Wyoming and Idaho. Rydberg (1900) gives the type locality as Mt. Queest, but "Mt. Avert" is given on the holotype.

Representative specimens examined: **CANADA. British Columbia:** Mt. Avert, 23 Jul 1889, J. M. Macoun *s.n.*(NY photo). **Alberta:** Banff National Park, Sunshine Meadows, 8 Sep 1991, *P. Achuff 6038* (MONTU). **U.S.A. MONTANA. Madison Co.:** Tobacco Root Mtns., Lily Lake, 7 Aug 1981, *Lackschewitz 10191* (MONTU); Noble Lake, 7 Aug 1994, *Vanderhorst 5300* (MONTU). **Park Co.:** Absaroka Mtns., Mount Wallace, 7 Aug 2001, *P. Lesica 8333* (MONTU).

Artemisia ludoviciana Nutt. ssp. **lindleyana** (Besser) P. Lesica, comb. nov. BASIONYM: *Artemisia lindleyana* Besser in Hook., Fl. Boreali-Amer. 1:322. 1833. TYPE: CANADA. BRITISH COLUMBIA: NW coast of America, *s.d.*, *Douglas s.n.* (LECTOTYPE: CGE photo! (Herb. Lindl. No. 16)) (vide Keck 1946: 454).

Artemisia lindleyana has been treated as a distinct species (Hitchcock & Cronquist 1973; Dorn 1984) or a subspecies of the European *A. vulgaris* L. (ssp. *lindleyana* H.M. Hall & Clements). The most recent treatment of *Artemisia* for North America (Shultz 2006) considers *A. lindleyana* conspecific with *A. ludoviciana* Nutt. Shultz (2006) recognized six subspecies within *A. ludoviciana*, and *A. lindleyana* was reduced to synonymy under ssp. *incompta* (Nutt.) Keck. Similar suffrutescent habit, flowers and involucre indicate a close relationship between *A. lindleyana* and *A. ludoviciana*. Within this complex both *A. ludoviciana* ssp. *incompta* and *A. lindleyana* have leaves that are glabrate above. However, the former has glabrate phyllaries, a paniculate inflorescence and deeply lobed leaves, while the latter has racemes of heads with tomentose involucres and leaves that are entire or nearly so. I agree with Shultz that *A. lindleyana* should be placed within *A. ludoviciana*, but believe that differences between *A. lindleyana* and *A. ludoviciana* ssp. *incompta* preclude subsuming the former in the latter. Shultz (2006) suggested that *A. lindleyana* may warrant infraspecific status under *A. ludoviciana*, and Cronquist stated that he had observed *A. lindleyana* growing adjacent to *A. ludoviciana* sensu stricto without intermediates (Hitchcock et al. 1955). For these reasons I propose *lindleyana* as a seventh subspecies of *A. ludoviciana*.

Artemisia ludoviciana ssp. *lindleyana* is found on sandy, gravelly or rocky banks of rivers from southern British Columbia to Oregon and east to Idaho and Montana west of the Continental Divide (Hitchcock et al 1955). The other three subspecies of *A. ludoviciana* in Montana generally occur in different habitats than ssp. *lindleyana*; ssp. *ludoviciana* occurs in grasslands, sagebrush steppe and meadows; ssp. *candicans* (Rydb.) Keck is found in grasslands, streambanks and roadsides; ssp. *incompta* (Nutt.) Keck occurs in stony soil of talus slopes, rock outcrops and sagebrush steppe. Montana's four subspecies have different combinations of a few variable characters and can be differentiated with the following key:

1. Leaves glabrate and greenish above.
    2. Phyllaries glabrate; inflorescence paniculate; leaves deeply lobed ______ ssp. **incompta**
    2. Phyllaries tomentose; inflorescence racemose; leaves entire to shallowly lobed ______ ssp. **lindleyana**
1. Leaves gray-tomentose on both surfaces.
    3. Leaves oblanceolate to obovate, at least the lower lobed ½-way to the midvein ______ ssp. **candicans**
    3. Leaves lanceolate, entire or shallowly lobed <½-way to midvein ______ ssp. **ludoviciana**

Representative specimens examined: **U.S.A. Montana. Flathead Co.:** Middle Fork Flathead River, 13 Aug 2004, *P. Lesica 8936* (MONTU). **Lake Co.:** Flathead Indian Reservation, Lower Flathead River, 22 Aug 1984, *S. Gregory 2894* (MONTU). **Mineral Co.:** Clark Fork River, 26 Oct 1978, *K. Lackschewitz 8799* (MONTU). **Missoula Co.:** Blackfoot River, Johnsrud Park, 19 Sep 1967, *M. Mooar 5559* (MONTU). **Sanders Co.:** Thompson Falls, 6 Aug 1901, *J. Blankenship 409* (MONT); sandy riverbanks, Thompson Falls, 2 Aug 1957, *W. Booth 571198* (MONT).

Symphyotrichum foliaceum (Lindl. ex DC.) G.L. Nesom var. **cusickii** (A. Gray) P. Lesica, comb. nov. BASIONYM: *Aster cusickii* A. Gray, Proc. Amer. Acad. Arts Sci. 16:99. 1880. TYPE: U.S.A. OREGON. Union Co.: mountains of Union Co., Jul–Aug 1878, *W.C. Cusick s.n.* (LECTOTYPE: GH photo!). *Aster foliaceus* Lindl. ex DC var. *cusickii* (A. Gray) Cronq., Amer. Midl. Naturalist 29:429–468. 1943. *Symphyotrichum cusickii* (A. Gray) G.L. Nesom, Phytologia 77:141–297. 1994.

Aster cusickii was first described by Asa Gray based on a Cusick collection from northeastern Oregon (Gray 1880). Sixty years later Cronquist argued that the plant graded into other forms of *A. foliaceus* and was best treated as a variety of that species (Cronquist 1943). Nesom moved the taxon into the genus *Symphyotrichum* and recognized it at the species level (Nesom 1994). In the most recent treatment of the group, Brouillet et al. (2006) also recognized the taxon at the species rather than at the infraspecific level. My review of mainly Montana material suggests that low-elevation segregates of *Symphyotrichum foliaceum* sensu lato from the Northern Rocky Mountains often cannot always be confidently distinguished from each other based on the plastic, continuous, vegetative characters purported to separate them (Cronquist 1943). Thus, I prefer to recognize this plant as a variety of *Symphyotrichum foliaceum* rather than at the species level; however, the desired combination had not been previously made. *Symphyotrichum foliaceum* var. *cusickii* can be distinguished from other varieties of *S. foliaceum* using keys presented by Cronquist (1943) and Hitchcock and Cronquist (1973).

ACKNOWLEDGMENTS

The review comments of John C. Semple (WAT) and one anonymous reviewer are gratefully acknowledged. Kanchi Gandhi (GH) and Nicholas Hind (MO) helped with nomenclatural advice.

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BOOK REVIEWS

Lynn M. Steiner. 2010. **Prairie-Style Gardens: Capturing the Essence of the American Prairie Wherever You Live.** (ISBN: 978-1-60469-003-3, hbk.). Timber Press, Inc., The Haseltine Building, 133 S.W. Second Avenue, Suite 450, Portland, Oregon 97204-3527, U.S.A. (**Orders:** www.timberpress.com, 800-327-5680). $34.95, 304 pp., 182 color photos, 1 map, 7" × 9".

Prairie-Style Gardens: Capturing the Essence of the American Prairie Wherever You Live is a motivating, beautiful book with many photographs of wildflowers and grasses found in American prairies. The book is divided into four chapters and includes profiles of flowers and grasses and sedges. It begins with a chapter about the inspiration for the prairie and by the time I finished that chapter I was hooked. Steiner clearly is enamored with the prairie plants and convinces the reader anyone can help re-create a bit of the prairie. The author conveys her passion for the prairie through her writing and photographs.

This book encourages the reader to add prairie plantings into the garden no matter how big or small the available space. Steiner makes a good case for restoring prairies and biodiversity. She shows great respect for the plants that survive through high winds, drought conditions, and repetitive disturbances. There are helpful tips throughout the book on everything from preparing the soil to winning the neighbors over with your natural landscape.

The Flowers Index is quite extensive with a colored photograph next to every detailed description. This is incredibly helpful to the novice prairie gardener. The information covers wildlife attraction, landscape uses, and native habitat. As I read the previous chapters I did find myself flipping to the index repeatedly so that I knew which flower she was currently referencing. Perhaps covering the flowers first in the book would alleviate this problem. The Grasses and Sedges section was a disappointment with only nine different species represented. Many of the photographs were captioned with both the scientific and common name while others only included the common name. It would be helpful to use both names throughout. Overall this is an inspiring book for any gardener, not just those already intrigued with native plants.

—*Julie Donovan, Coordinator of Volunteers, BRIT, 1700 University Drive, Fort Worth, Texas 76107-3400, U.S.A.*

Marty Wingate. 2011. **Landscaping for Privacy: Innovative Ways to Turn Your Outdoor Space into a Peaceful Retreat.** (ISBN: 978-1-60469-123-8, pbk.). Timber Press, Inc., The Haseltine Building, 133 S.W. Second Avenue, Suite 450, Portland, Oregon 97204-3527, U.S.A. (**Orders:** www.timberpress.com, 800-327-5680). $19.95, 155 pp., color photos, 8" × 9".

Andrew Buchanan's book cover photograph serves as the subliminal concierge to Marty Wingate's *Landscaping for Privacy: Innovative Ways to Turn Your Outdoor Space into a Peaceful Retreat.*

Ms. Wingate's book is a clearly visible written example of her landscape gardening/design prowess. In addition, it demonstrates she is a savvy author who has garnered an extraordinarily talented team of professional photographers, book designers, and a well known publisher of books on gardening, horticulture, etc.

The reader's sojourn into the Table of Contents will ensure the reader will turn the next page. While the writing is for a general readership, it is cerebral fodder for soundscape ecologists. It is notable for the striking fidelity of its illustrations, photographs, and the ease with which they provide identification of buffers, barriers, screens, and plant lists. Plant lists offer ideas for readers to consider for optimum landscape privacy design. Scientific and common plant names are included in each category of the listings. Also, an extensive index cross indexes scientific plant names and common names. In addition, conversion tables, plant hardiness zones and resource names/websites are included at the end of the text.

Why wait to develop innovative ways to turn your outdoor space into a peaceful retreat?

—*Kay M. Stansbery, Ph.D., Library volunteer,*
Botanical Research Institute of Texas, 1700 University Dr., Fort Worth, Texas 76107-3400, U.S.A.

LOMATIUM BRUNSFELDIANUM:
A NEW SPECIES OF *LOMATIUM* (UMBELLIFERAE) FROM NORTHERN IDAHO

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ABSTRACT

Lomatium brunsfeldianum Kemper & R.P. McNeill is a new species described from four populations in Idaho: the Lochsa River Canyon, North Fork of the Clearwater River Canyon, St. Joe River Canyon, and along the Couer d'Alene River. It is morphologically most similar to *Lomatium bicolor* var. *bicolor* and *L. grayi* var. *grayi*. It can be distinguished from *Lomatium bicolor* var. *bicolor* by the wide geographical separation, distinctive umbel structure, root morphology, and different habitat, and can be distinguished from *Lomatium grayi* var. *grayi* by the characters of the mericarps, papillae in the umbel, root structure, and ecological separation. *Lomatium brunsfeldianum* occurs congruently with *Lomatium ambiguum* and *Lomatium dissectum* var. *multifidum*, but is easily distinguishable from either based on morphology.

RESUMEN

Lomatium brunsfeldianum Kemper y R.P. McNeill es una nueva especie descrita de cuatro poblaciones en Idaho: el Cañón Lochsa Rivera, North Fork del Cañón del río Clearwater, Cañón del río St. Joe, y a lo largo del río Coeur d'Alene. Es morfológicamente muy similar a *Lomatium bicolor* var. *bicolor* y *L. grayi*. Se puede distinguir de *Lomatium bicolor* var. *bicolor* por la separación geográfica amplia, distinta estructura de la umbela, morfología de la raíz, y hábitat diferentes, y se puede distinguir de *Lomatium grayi* var. *grayi* por los caracteres de los mericarpos, las papilas de la umbela, estructura de la raíz, y la separación ecológica. *Lomatium brunsfeldianum* aparece en congruencia con *Lomatium ambiguum* y *Lomatium dissectum* var. *multifidum*, pero es fácilmente distinguible de cualquiera por su morfología.

KEY WORDS: New Species, *Lomatium*, Umbelliferae, Apiaceae, Idaho, Northern Rocky Mountains, Endemic

Lomatium brunsfeldianum Kemper & R.P. McNeill, sp. nov. (**Figs. 1–5**). TYPE: UNITED STATES. IDAHO. Idaho Co.: Blackrock Canyon, Lochsa River, ca. 0.4 mi E of Split Cr. along HWY 12, on rock out crop, ca. 1800 ft (046°121'16.33"N, 115°24'10.85"W), 30 May 2003, *Kemper 93* (HOLOTYPE: ID).

Lomatium bicolor (S. Watson) J.M. Coult. & Rose var. *bicolor*, Contr. U.S. Natl. Herb. 7:237. 1900. *Peucedanum bicolor* S. Watson, Bot. King Surv. 129. 1871. *Cogswellia bicolor* (S. Watson) M.E. Jones, Contr. W. Bot. 12:33. 1908.

Lomatium brunsfeldianum differs from congeners by geographical and/or ecological separation, umbel structure, root morphology, and leaf size and structure.

Plantae perennes, caule, 37–86 cm procerae ubi maturae. Radix cylindracea, carnosa, ramosa, caudice simplici vel ramoso. Caulis uno ad aliquot, deliquescenes, nervocaulis, glabri ad dense papillosi, 10–30 cm longi. Folia uno ad aliquot per caulis, trullata, alterna, basilia et caulina, glaberi ad dense papillosi, ternato-pinnati dissecti, bis ad sexies divisi, 13–33 cm longi, 17–48 cm lati; petioli amplexicauli; segmentis ultimis 30–71 per cm^2, filiformibus vel linearibus; apicibus subtiliter mucronatis, 0.73–4.12 mm longis, 0.14–0.62 mm latis. Scapi 1–2, 4.4–40.1 cm longi. Inflorescentia umbella composita, spara ad dense papillousa; radiis 5–16, papillosis, effusis, 1.2–12.8 cm longis; pedicellis 4–19, caespitosis 2.9–10.1 mm longis; involucrum absens; bractis minores ex invollucelli ± praesentibus, descretis, filiformibus vel linearibus, ut maximun 4 mm longis, ut maximum 0.2 latis. Flores sepali 5, connatis, inconspicuous; petali flavis, obcordatis; filo flavis, complantanis; antheris 2, flavis, exsertis. Mericarpia anguste elliptica, dorsaliter compresa, 10.75–15.63 mm longa, 3.06–4.61 mm lata; alibus lateralibus 0.29–0.99 mm latis; vittis intervallis 1–2, commissuris 2–6, ± obscuribus vel incompletibus; stylopodia luteola, laevia at paleaceoa; carpophorum luteolum 9–14 mm longum. Florescentia March per June. Plantae occupanes sitibus humidis, petrosis.

Plants caulescent perennial, 37–86 cm tall at maturity; **root** cylindric, fleshy, branched, simple to branched caudex. **Stems** 1-several, deliquescent, shallowly corrugated, glabrous to densely papillate, 10–30 cm long. **Leaves** 1-several per stem, alternate; **petiole** sheathing stem; **blades** trullate, glabrous to densely papillate, ternate-pinnately dissected, 2–6 times divided, 13–33 cm long, 17–48 cm wide; **ultimate segments** 30–71 per 1 cm^2, filiform or linear, with mucronulate apices, 0.73–4.12 mm long, 0.14–0.62 mm wide. **Scapes** 1–2, 4.4–40.1 cm long. **Inflorescence** compound umbel, sparsely to densely papillate; **involucre** absent; **rays** 5–16,

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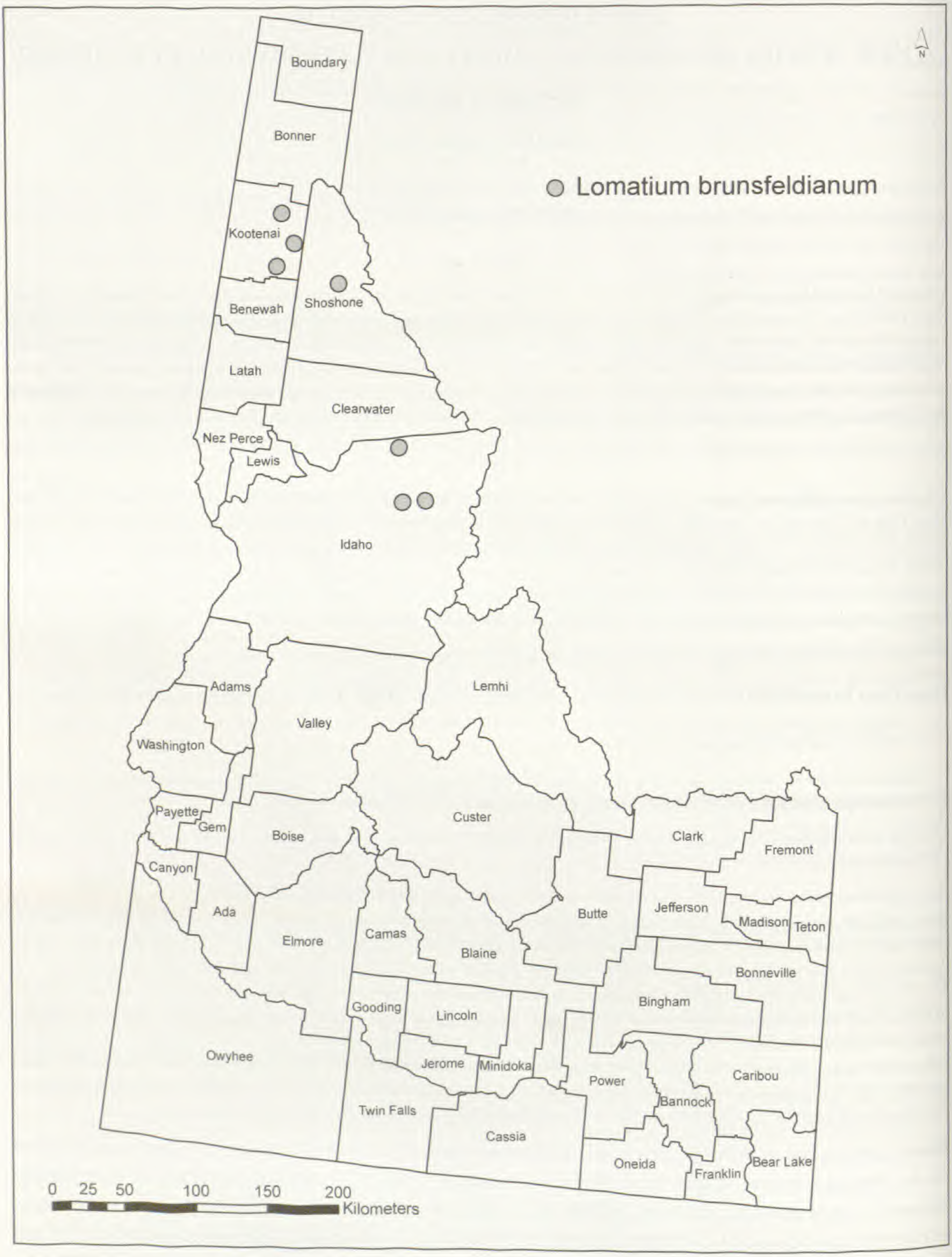
Lomatium brunsfeldianum
N
Boundary
Bonner
Kootenai
Benewah
Shoshone
Latah
Clearwater
Nez Perce
Lewis
Idaho
Adams
Washington
Valley
Lemhi
Payette
Gem
Boise
Custer
Clark
Fremont
Canyon
Ada
Elmore
Camas
Blaine
Butte
Jefferson
Madison
Teton
Bonneville
Bingham
Gooding
Lincoln
Jerome
Minidoka
Owyhee
Power
Bannock
Caribou
Twin Falls
Cassia
Oneida
Franklin
Bear Lake
0 25 50 100 150 200
Kilometers

Fig. 1. Geographic range of *Lomatium brunsfeldianum*.

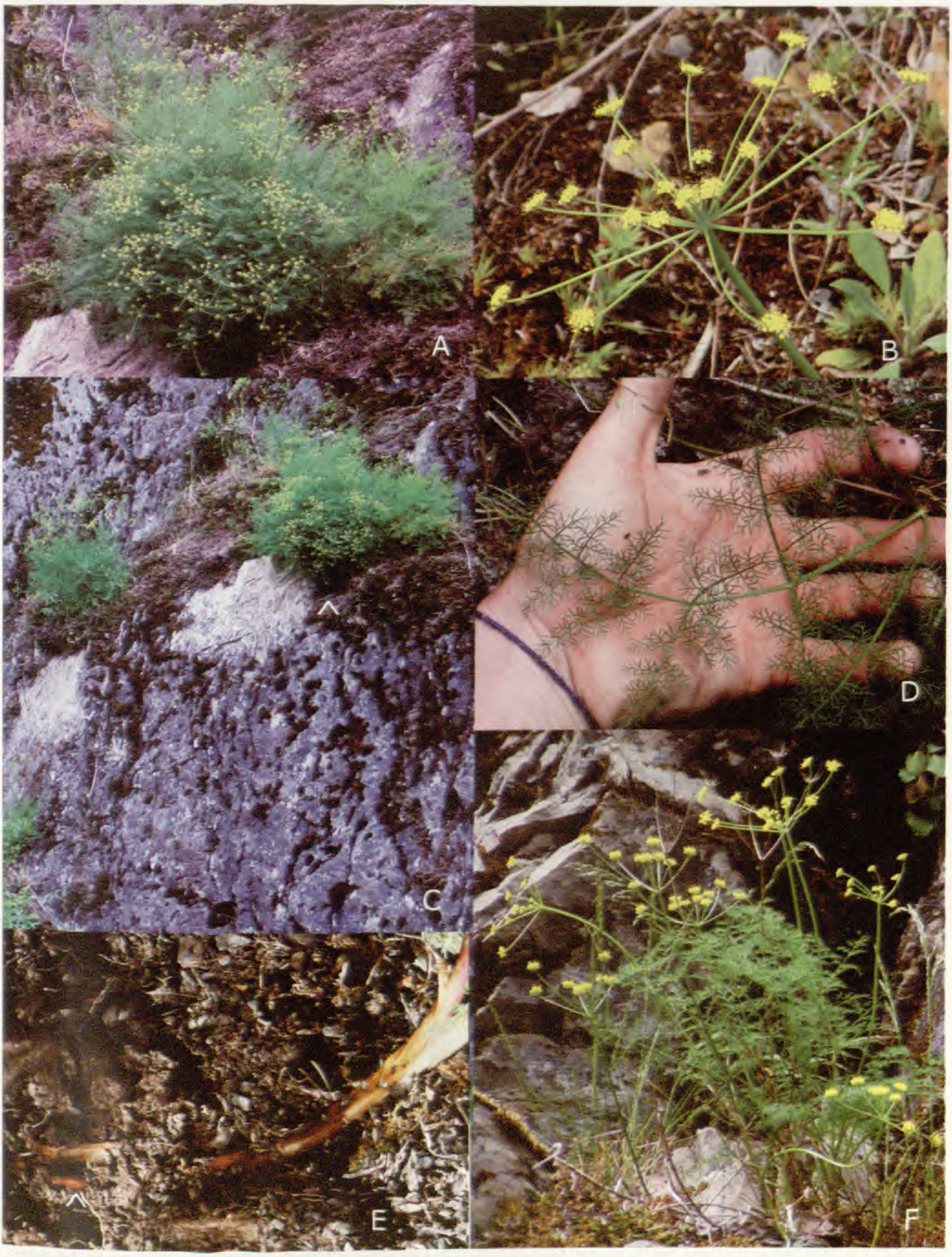

FIG. 2. *Lomatium brunsfeldianum*. A. Large plant, notice three dimensional nature of leaves. B. Divaricate rays of the umbel. C. Same plant as A showing rocky habitat. D. Filiform ultimate segments. E. Branching root. F. Small plant with old stems and umbels.

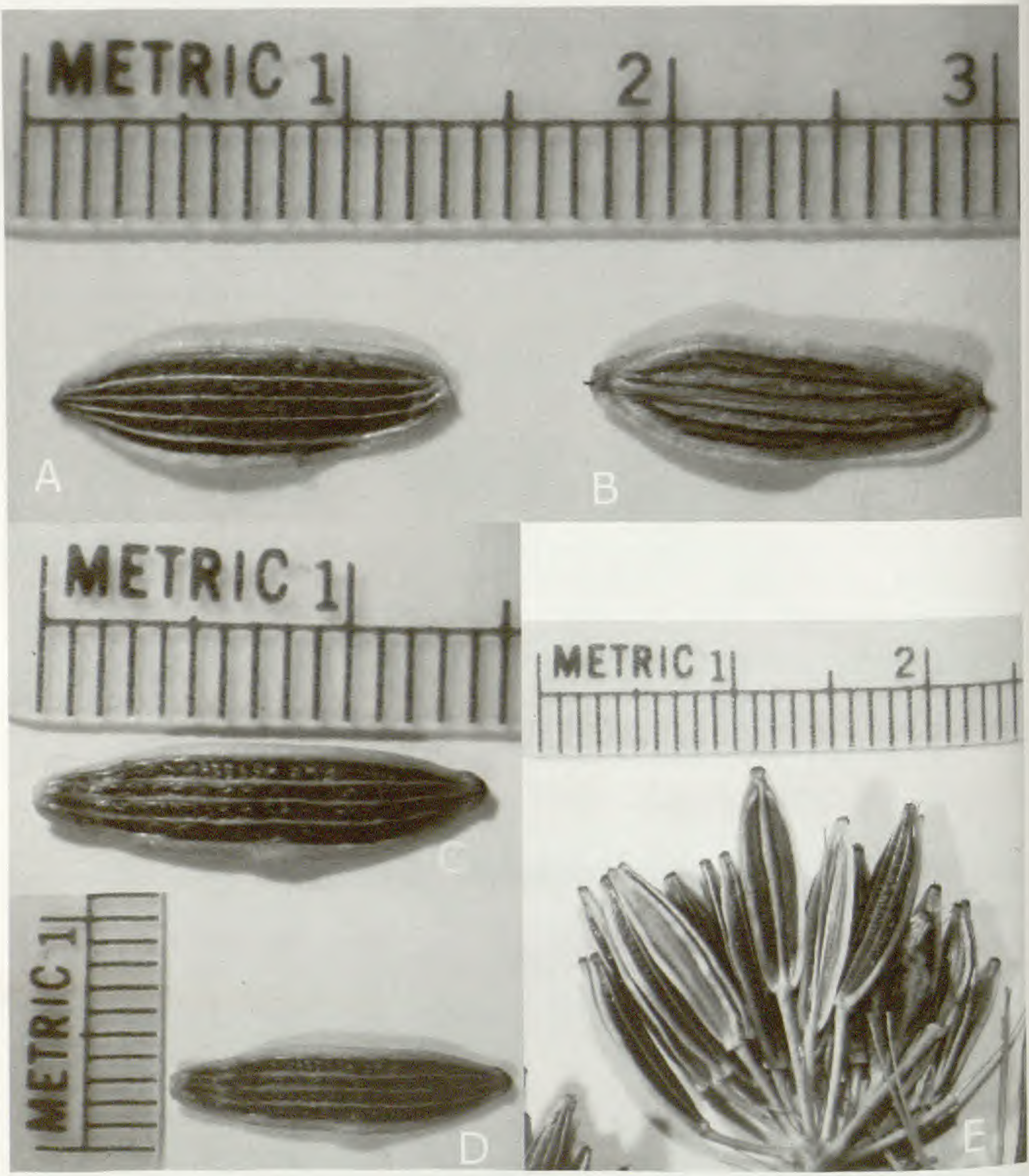

Fig. 3. *Lomatium brunsfeldianum*. A. Mericarp, dorsal view with five vittae, one in each interval. B. Mericarp, commissural view with six vittae, three of which are incomplete. C. Mericarp, dorsal view with four vittae, one in each interval. D. Mericarp showing width. E. Umbellet with mericarps and carpophore.

papillate, divaricate, 1.2–12.8 cm long; **pedicels** 4–19, caespitose, 2.9–10.1 mm long; **involucel bractlets** ± present, free, linear or filiform, up to 4 mm long, up to 0.2 mm wide. **Flowers sepals** 5, connate, inconspicuous; **petals** 5, yellow obcordate; **anthers** 2, yellow, exserted; **filaments** flattened, yellow; **superior ovary**, carpel 2, styles 2. **Mericarps** narrowly elliptic, deplanate, 10.75–15.63 mm long, 3.06–4.61 mm wide, lateral wings 0.29–0.99 mm wide; **vittae** interval 1–2, commissural 2–6, may be obscure, or incomplete; **stylopodia** yellow, smooth to paleaceous; **carpophore** yellow, 9–14 mm long. Flowering March through June. Occurring on wet rocky outcrops and talus slopes.

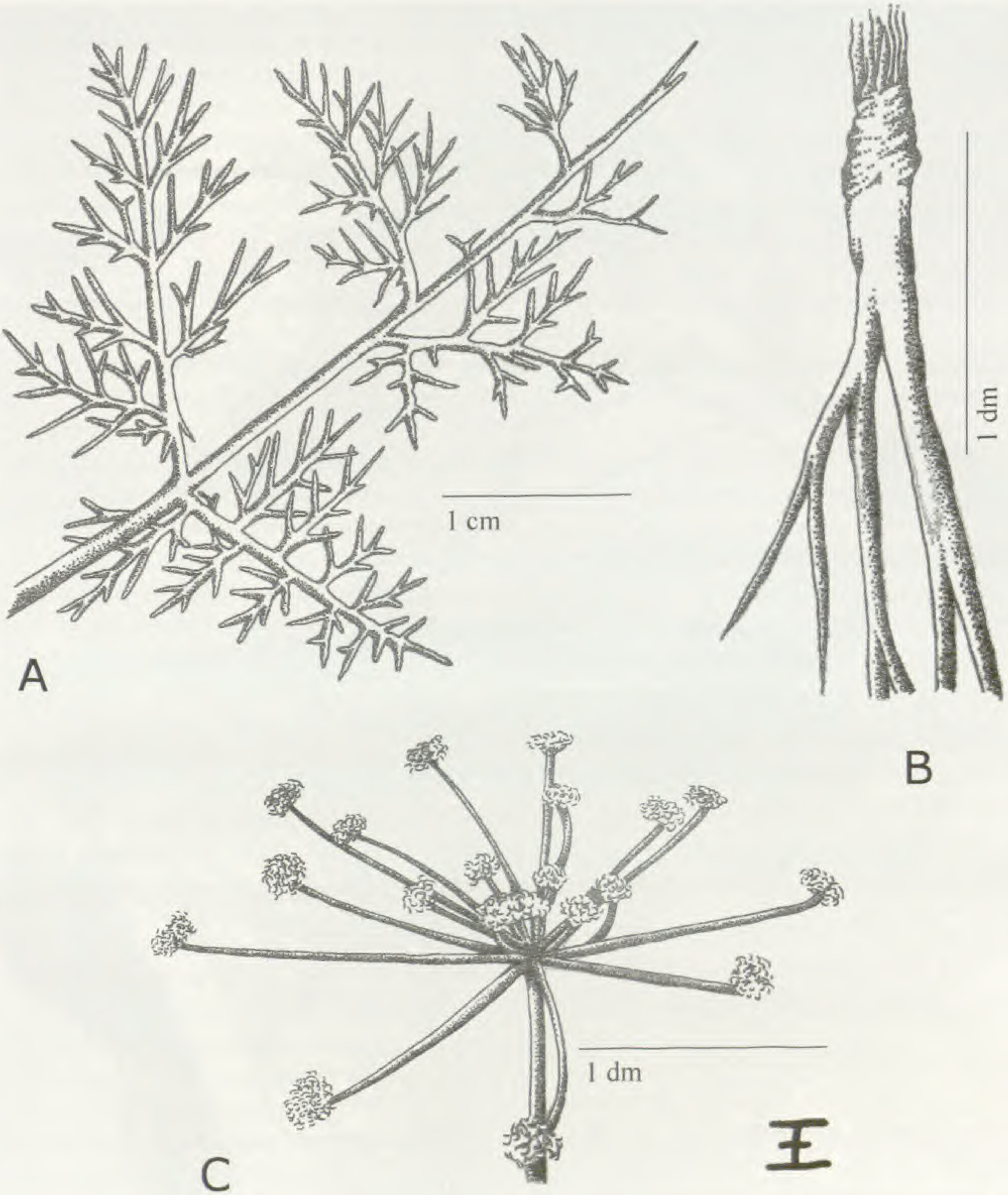

Fig. 4. ***Lomatium brunsfeldianum*****. A. Leaf structure. B. Root and caudex. C. Umbel structure.**

Additional specimens examined: **U.S.A. IDAHO. Idaho Co.:** Blackrock Canyon, Lochsa River, ca. 0.4 mi E of Split Cr. Along HWY 12, on rock out crop, ca. 1800 ft (046°121'16.33"N, 115°24'10.85"W); 30 May 2003, *Tyson Kemper 93* (ID); North Fk. Clearwater River, SSW facing cliff complex adjacent to road, some seepy spots (046°50.422'N, 115°33.317'W; 046°39.080'N, 115°31.881'W); 16 Jun 2004, *Tyson Kemper 266* (ID); Clearwater Range Just S of mouth of Tumble Creek W of Lochsa River, E aspect (T34N R8E SW ¼ of the SE ¼ Sec. 25), 24 May 1993, *Karen Gray 27* (ID). **Kootenai Co.:** growing on mossy rock out-crops NW side of Rose LK (N 047°33.586', W 116°27.641'); 23 June 2004, *Tyson Kemper 287* (ID); rock cliff complex on Rd. 108 ca. 7 mi E of Couer d'Alene SSE aspect (N 047°42.957', W 116°40.082'); 23 Jun 2004, *Tyson Kemper 288* (ID); W margin of Rose Lake Bog, growing on a dry mossy cliff immediately above West Shore Rose Lake Road, 17 Jul 2002, *Curtis R. Bjork 6481* (ID). **Shoshone Co.:** Couer d'Alene River, SE aspect growing in rock out crop along road cut in cracks and in steep loose rocky soil (N 047°37.225', W 116°12.833'); 24 Jun 2004, *Tyson Kemper 308* (ID)

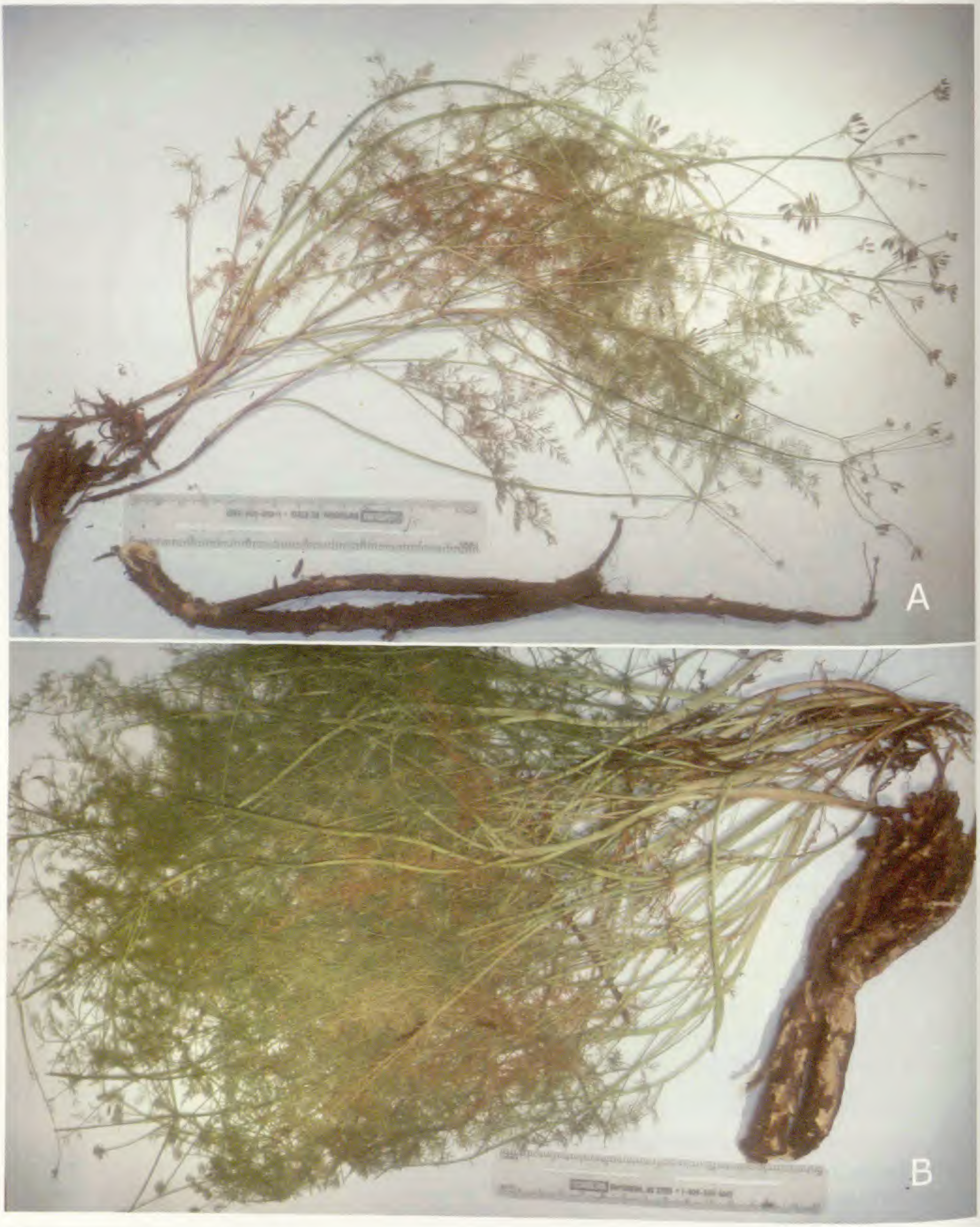

Fig. 5. ***Lomatium brunsfeldianum*****. Two pressed specimens from the Lochsa River Canyon.**

Etymology.—The specific epithet commemorates Dr. Steven J. Brunsfeld's contributions to the fields of botany and education.

Distinctive landforms and geomorphic processes in conjunction with large-scale processes of climate change have resulted in unusual patterns of plant distribution in the Northern Rocky Mountains of the U.S.A.

Consequently, it is home to many rare and endemic species, and many disjunct populations of species that are normally distributed either west of the Cascade Mountains or east of the Rocky Mountains (Brunsfeld et al. 2001). In 2003, an anomalous population of *Lomatium* was discovered in the Lochsa River Canyon by Tyson Kemper. Additional populations were later found on the North Fork of the Clearwater, St. Joe and Couer d'Alene rivers. It was not possible to key specimens from these populations reliably in the Flora of the Pacific Northwest or the Intermountain Flora (Cronquist et al. 1994; Hitchcock et al. 1961). Morphologically specimens from these populations were found to be somewhat similar to both *Lomatium bicolor* (S. Watson) J.M. Coult. & Rose var. *bicolor and L. grayi* (J.M. Coult. & Rose) J.M. Coult. & Rose var. *grayi* (Fertig 2000). It was concluded, however, that differences in morphology, ecology, and/or geography were significant enough that these populations should be recognized as a new species, *L. brunsfeldianum*. The characters distinguishing *L. brunsfeldianum* from *L. bicolor* var. *bicolor* and *L. grayi* var. *grayi* are discussed below.

The morphological characters of *Lomatium brunsfeldianum* easily distinguish it from other *Lomatium* species, with the exceptions of *L. bicolor* var. *bicolor*, and *L. grayi* var. *grayi*. *Lomatium bicolor* var. *bicolor* is similar in leaf structure, and mericarp size and shape. It also has overlap in all of the size measurements with *L. brunsfeldianum*, but with a much smaller statistical mean. There are four main characters that allow the two species to be separated. The most obvious is the large separation in geographical range. There is approximately 400 km separation between the known occurrences of the two taxa. The root structure is also very different; *L. bicolor* var. *bicolor* has moniliform, globose, or tuberous roots that are un-branched and somewhat woody, while *L. brunsfeldianum* has cylindric, fleshy roots that may have multiple branchings (Harris & Woolf Harris 2003). *Lomatium brunsfeldianum* occurs on rocky outcrops and talus slopes, which is very different from the wet meadows and high clay content soils of *L. bicolor* var. *bicolor* habitat. *Lomatium brunsfeldianum* has a very distinctive umbel structure with numerous (5–16), long (12–127 mm), divaricate rays, while *L. bicolor* var. *bicolor* has fewer (2–9), shorter (7–81 mm), caespitose rays. When Schlessman (1984) described *L. bicolor* var. *bicolor*, he included some samples of *L. brunsfeldianum* as *L. bicolor* var. *bicolor*. There were few specimen of *L. brunsfeldianum* collected at that time, which made it difficult to separate from *L. bicolor* var. *bicolor*. *Lomatium grayi* var. *grayi* is distinguished from *L. brunsfeldianum* by the structure and size of the mericarps, a stout taproot, lack of papillae in the umbel, and it is essentially acaulescent, with the leaves apparently basal, while *L. brunsfeldianum* is caulescent. *Lomatium grayi* occurs on sites that are much dryer than sites where *L. brunsfeldianum* is found and generally at lower elevations in north Idaho. *Lomatium bicolor* var. *leptocarpum* is very different from *L. brunsfeldianum*, with the only similarity being the mericarps. It has been considered in this paper because it is the only variety of *L. bicolor* that occurs in north Idaho.

Lomatium brunsfeldianum has only been found in four deep river canyons of northern Idaho: the Lochsa River Canyon, the North Fork of the Clearwater River Canyon, the St. Joe River Canyon, and the Couer d'Alene River Canyon (see Fig. 1). *Lomatium brunsfeldianum* occurs only on moist rocky outcrops, talus slopes, and soil at the base of cliffs in the river valleys and canyons in the mesic cedar/hemlock forest of northern Idaho between 480–1800 m in elevation. The soil it occurs on in the St. Joe River canyon was classified as an Udorthent, which are young well-mixed soils with no horizon development, a high portion of rock fragments, a low clay fraction, and an udic moisture regime (Soil Survey Staff 2003). The sites where it occurs have a south aspect and are possible ground water discharge areas. *Lomatium brunsfeldianum* flowers from March to early June and the fruit matures in late June through August with timing largely dependent on elevation and exposure. *Lomatium brunsfeldianum* occurs in association with the following species: *Alnus rubra* Bong., *Amelanchier alnifolia* (Nutt.) Nutt. ex. M. Roem., *Centaurea stoebe* L. ssp. *micranthos* (Gugler) Hayek, *Claytonia cordifolia* S. Watson, *Collinsia parviflora* Lindl., *Fragaria vesca* L., *Holodiscus discolor* (Pursh) Maxim., *L. ambiguum* (Nutt.) J.M. Coult. & Rose, *L. dissectum* (Nutt.) Mathias & Constance var. *multifidum* (Nutt.) Mathias & Constance, *Mimulus clivicola* Greenm., *M. guttatus* DC., *Orobanche fasciculata* Nutt., *Penstemon wilcoxii* Rydb., *Philadelphus lewisii* Pursh, *Pinus ponderosa* C. Lawson, *Poa bulbosa* L., *Pseudotsuga menziesii* (Mirb.) Franco var. *menziesii*, and *Sedum stenopetalum* Pursh.

Lomatium brunsfeldianum is endemic to the Northern Rocky Mountains of Idaho and should be considered for listing as a sensitive or threatened species due to its limited geographic range. It occurs on the north side of river drainages, which is also where most of the major roads are located. This puts *L. brunsfeldianum* at risk in a number of ways: encroachment by invasive species introduced by the initial road building and spread by current road maintenance and traffic, habitat destruction caused by additional road building, and eradication through herbicide application. Future efforts should focus on a more thorough mapping of this and other plant species in Idaho and integration of this data into management plans.

1. Involucel bractlets absent.
    2. Ultimate segments leaf-like, narrowly trullate to narrowly obtrullate, 1–20 per cm², 0.5–54 mm long, up to 5 mm wide, scapes 1–8(–13) **L. ambiguum**
    2. Ultimate segments not leaf-like, filiform, more than 20 per cm², 0.7–5.5(–7) mm long, 0.1–0.7 mm wide, scapes 1–4.
        3. Roots cylindric, fleshy, branched, pedicels 2.9–10.2 mm long, rays divaricate **L. brunsfeldianum**
        3. Roots tuberous thickened, globose, moniliform, or elongate thickened, pedicels 0.7–3.5 mm long, rays caespitose or ascending **L. bicolor** var. **bicolor**
1. Involucel bractlets present.
    4. Ultimate segments very numerous, several hundred to several thousand, terete in cross section, involucel bractlets dimidiate, strong carrot or celery odor **L. grayi** var. **grayi**
    4. Ultimate segments less numerous, rarely more than 150, flat, involucel bractlets various, but not dimidiate, no strong odor.
        5. Plants 5–15(–20) dm tall, pedicels 4–20 mm long, mericarps 4.5–10 mm wide, large woody taproot **L. dissectum** var. **multifidum**
        5. Plants less than 5 dm tall, or if more than 5 dm then pedicels 3.5 mm or less long, or roots cylindric, fleshy and branched.
            6. Roots cylindric, fleshy, branched, pedicels 2.9–10.2 mm long **L. brunsfeldianum**
            6. Roots tuberous thickened, globose, moniliform, or elongate thickened, pedicels 0.7–3.5 mm long.
                7. Ultimate segments not leaf-like, filiform, 21–110 per cm², (0.3–)0.9–5.5(–7) mm long, 0.2–0.6 mm wide **L. bicolor** var. **bicolor**
                7. Ultimate segments leaf-like, narrowly oblong, narrowly trullate, or narrowly elliptic, 4–34 per cm², (0.25–)0.9–19.5 mm long, 0.2–1.5mm wide **L. bicolor** var. **leptocarpum**

ACKNOWLEDGMENTS

I would like to thank Pam Brunsfeld, Ronald L. Hartman, Mark Schlessman, Curtis Bjork, and Matt Parks for their help with this research. The following herbaria kindly assisted with loans: Stillinger Herbarium (ID) University of Idaho, Moscow; Rocky Mountain Herbarium (RM) University of Wyoming, Laramie; University of Montana (MONTU) Missoula; Missouri Botanical Gardens (MO) St. Louis; Montana State University (MONT) Bozeman; Colorado State University (CS) Fort Collins. I would also like to thank Mary Ann Feist and Ronald L. Hartman for helpful reviews and Barney Lipscomb for his help and patience in getting this paper published.

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MICONIA CORDIERI, A NEW SPECIES OF *MICONIA* SECT. *SAGRAEA* (MELASTOMATACEAE) FROM THE MACAYA BIOSPHERE RESERVE, HAITI

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ABSTRACT

A new species of *Miconia* sect. *Sagraea*, endemic to the floristically diverse Massif de la Hotte of southwestern Haiti and discovered during the course of a systematic revision of the Caribbean species of this section, is described and illustrated. The discovery of **Miconia cordieri** brings to 15 the number of described species of *Miconia* sect. *Sagraea* known from the Morne Formon-Pic Macaya region of the Massif de la Hotte, nine of which are endemic to the Massif de la Hotte.

Key Words: Haiti, Macaya Biosphere Reserve, Massif de la Hotte, Melastomataceae, *Miconia*, *Sagraea*

RESUMEN

Se describe e ilustra una especie nueva de *Miconia* sect. *Sagraea*, que es endémica del florísticamente diverso Macizo de la Hotte, localizado al suroeste de Haití. Esta especie fue descubierta en el transcurso de la revisión sistemática de las especies caribeñas de esta sección. El descubrimiento de **Miconia cordieri** eleva a 15 el número de especies descritas en *Miconia* sect. *Sagraea* conocida de la región de Morne Formon-Pic Macaya del Macizo de la Hotte, nueve de las cuales, son endémicas de este Macizo.

Palabras Claves: Haití, Reserva de la Biosfera Macaya, Masizo de la Hotte, Melastomataceae, *Miconia*, *Sagraea*

While conducting a systematic revision of the Caribbean species of *Miconia* Ruiz & Pavon section *Sagraea* (DC.) Ionta, Judd & Skean, two specimens collected in 1984 and 1989 in the Parc National Pic Macaya, Massif de la Hotte, Haiti and identified as *Ossaea curvipila* Urb. & Ekman (*Miconia curvipila* (Urb. & Ekman) Ionta, Judd & Skean) were examined and determined to represent an undescribed species in the section. Species of *Miconia* sect. *Sagraea* are easily differentiated from other *Miconia* species by their axillary, four-merous flowers with well-developed calyx teeth (Judd 1986a, 1989), and the presence of minute, subsessile to short-stalked, furrowed gland-headed hairs on vegetative surfaces (Ionta et al. 2012). Until recently *Sagraea* was recognized as a genus within Miconieae (Judd 1989; Liogier 2000) or treated as a section within *Clidemia* (Cogniaux 1891). A number of recent phylogenetic analyses (Michelangeli et al. 2004, 2008; Goldenberg et al. 2008; Martin et al. 2008) confirmed the monophyly of *Sagraea*, but at the same time revealed that nearly all of the genera of Miconieae, including *Miconia*, itself, are polyphyletic (Michelangeli et al. 2004, 2008; Goldenberg et al. 2008; Becquér-Granados et al. 2008; Martin et al. 2008). The most plausible solution to this classificatory problem (as clearly evident in Figs. 1–3 of Goldenberg et al. 2008, or Fig. 1 of Michelangeli et al. 2008) is to place most species of Miconieae (including *Sagraea* species) within a greatly expanded *Miconia*, comprising the molecular-supported clade within Miconieae that can be diagnosed by the synapomorphy of berry fruits (Ionta et al. 2012). Thus we describe this new species as *Miconia cordieri*.

Miconia cordieri is morphologically most similar to the la Hotte endemic *M. woodsii* (Judd & Skean) Ionta, Judd & Skean, and to a complex of species that includes the la Hotte endemics *M. curvipila*, *M. lanceifolia* (Urb.) Ionta, Judd & Skean, *M. rubisetulosa* Ionta, Judd & Skean, and the Hispaniolan endemic *M. ellipsoidea* (Urb. & Ekman) Ionta, Judd & Skean; species delimitations and relationships within this "*M. ellipsoidea*" species complex are being investigated by the first author, and a consideration of these delimitations is beyond the scope of this paper. *Miconia cordieri, M. woodsii,* and the members of the *M. ellipsoidea* complex have a number of features in common, most notably the presence of minute, subsessile to short-stalked pseudopeltate hairs with flattened branches on abaxial leaf surfaces, which are likely homologous to the short-stalked, furrowed gland-

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headed hairs typical of (and putatively synapomorphic for) most other species of *Miconia* sect. *Sagraea*. These distinctive, flattened hairs are also present in a group of related species (differentiated from the previously mentioned species by their square, winged stems) that includes *M. hottensis* Ionta, Judd & Skean, *M. navifolia* Ionta, Judd & Skean, *M. capillaris* (Sw.) M. Gomez (the hairs peltate in *M. capillaris*), and *M. tetraptera* (Cogn.) Ionta, Judd & Skean (Ionta et al. 2012), and may prove to be synapomorphic for this entire group of species.

Miconia cordieri, exhibiting a distinctive combination of morphological characters, satisfies the definitions of the morphological-phenetic (Judd 2007) and diagnostic (Wheeler & Platnick 2000) species concepts. The most distinctive feature differentiating *Miconia cordieri* from *M. woodsii* and from species in the *M. ellipsoidea* complex is the presence of simple, erect, multiseriate hairs (0.1–0.3 mm long) scattered sparsely on the veins and on the abaxial leaf lamina (arising from veinlets). Simple hairs are absent from the abaxial leaf surfaces of *M. woodsii*, and in the species of the *M. ellipsoidea* complex they are present only on quaternary veins and higher, and the hairs tend to be longer (e.g., from 0.3–0.7 mm long in *M. ellipsoidea*, and to 1.3 mm long in *M. rubisetulosa*) and more densely distributed. The pattern of simple hairs on the stems of these plants mirrors that of the abaxial leaves, i.e., simple stem hairs are absent in *M. woodsii*, short erect hairs are scattered on the stems of *M. cordieri*, and more densely distributed, longer hairs are typical of species in the *M. ellipsoidea* complex. Dendritic hairs, which are present on the stems of many species of *Miconia* sect. *Sagraea*, can be diagnostically important. The stems of *M. cordieri* and *M. woodsii* are densely covered with sessile to stalked globular dendritic hairs (to 0.2 mm long in *M. cordieri*, to 0.1 mm long in *M. woodsii*); these hairs are also scattered on the major abaxial veins, particularly along the midvein adjacent to the petiole. Dendritic hairs on the stems of species in the *M. ellipsoidea* complex are more sparsely arranged than in *M. cordieri* and *M. woodsii*, and tend to be sessile to very short-stalked (occasionally to 0.1 mm long in *M. rubisetulosa*).

The leaves of *Miconia cordieri* are morphologically similar to those of *M. woodsii* and species in the *M. ellipsoidea* complex. In these species, the leaves are more or less elliptic (often elongate to narrowly ovate in some species), bullate (to varying degrees within and among species), with scattered, stiff setae on the adaxial surface, serrulate margins, and adaxial surfaces that tend to turn dark maroon when dry. In *M. cordieri* and species in the *M. ellipsoidea* complex, abaxially raised percurrent intertertiary veins are common. In *M. woodsii*, percurrent intertertiary veins are uncommon, and when they occur they are indistinct and not raised abaxially.

Inflorescence morphology of *Miconia cordieri* is similar to that of *M. woodsii* and most species in the *M. ellipsoidea* complex from the la Hotte region, i.e., few-flowered, compact inflorescences (e.g., up to 5 flowers in inflorescences up to 4.5 mm long in *M. cordieri*, and 7 flowers in inflorescences up to 8 mm long in *M. woodsii*), the exception being *M. rubisetulosa*, which has up to 12 flowers in longer, less compact inflorescences to 24 mm long. Floral traits that differentiate *M. cordieri* and *M. woodsii* from species in the *M. ellipsoidea* complex include hypanthium shape and size (± cylindrical, flaring distally, and to 1.6 mm long in *M. cordieri* and *M. woodsii*, vs. urceolate and to 2.5 mm long in members of *M. ellipsoidea* complex), indumentum (low warty projections present on proximal half of hypanthium in *M. ellipsiodea* complex are absent in *M. cordieri* and *M. woodsii*), and ornamentation of the inner hypanthium surface and the lower rim of hypanthium tube (the lower rim in *M. cordieri* and *M. woodsii* appearing scalloped, with 8 low triangular projections corresponding to the insertion points of the stamens and extending down the inner hypanthium and forming low ridges, and the lower rim of the hypanthium tube ringed with a fringe of inwardly-oriented hairs, vs. inner hypanthium surface and rim glabrous, smooth, and un-ornamented in species of the *M. ellipsoidea* complex).

Other floral features distinguishing *Miconia cordieri* from *M. woodsii* include the presence of stout, conical, somewhat curved hairs to 0.3 mm long on the hypanthium (absent in *M. woodsii*, and multiseriate hairs of species of *M. ellipsoidea* complex longer and thinner, and not conical, when present), elongate, gland-tipped hypanthium hairs (absent in *M. woodsii*, but common in species in the *M. ellipsoidea* complex), and ovary position (½ inferior in *M. cordieri*, ⅔ inferior in *M. woodsii*, and mostly inferior, except for the collar, in other species, but we note that data are based on only ten collections, and ovary position tends to vary infraspecifically in *Miconia*).

Morne Formon, Morne Macaya, and the Gran Ravine du Sud comprise the core area of the Macaya

Biosphere Reserve (Sergile et al. 1992; Woods & Ottenwalder 1992), an extraordinary area of species endemism in the Massif de la Hotte (Haiti) that continues to yield new angiosperm species (see Ackerman & Whitten 2010; Judd et al. 2008). *Miconia cordieri* is known only from a few isolated fragments of original vegetation in cut-over moist broadleaved forests (i.e., *rak bwa*) on rough "dog-tooth" limestone at the southern base of Morne Formon, from 950 to1190 m on the ridge just below (south) of Ville Formon and between Ville Formon and the "Experiment Station" on the Deron Plain (west-northwest of Formon). For a detailed map showing the locations of Morne Formon, the Deron Plain, and the karstic ridge just S of Ville Formon see Woods & Harris (1986, Map 4). The vegetation of the Formon region (sometimes spelled Formond) is described in Ekman (1928), Judd (1987) and Judd et al. (1990, 1998).

The Massif de la Hotte, the westernmost mountain range on the Tiburon peninsula of Haiti, harbors many interesting species of Melastomataceae (see Judd 2007; Skean 1993). Other melastomes occurring in the vicinity include *Calycogonium apiculatum* Urb. & Ekman, *C. formonense* Judd, Skean & Clase, *C. torbecianum* Urb. & Ekman, *Clidemia umbellata* (Mill.) L. O. Williams, *Mecranium birimosum* (Naudin) Triana, *M. haitiense* Urb., *M. revolutum* Skean & Judd, *Meriania brevipedunculata* Judd & Skean, *Miconia pyramidalis* (Desr.) DC., *M. rubrisetulosa*, *M. subcompressa* Urb., *M. tetrastoma* Naud., and *Tibouchina longifolia* (Vahl.) Baill. ex Cogn.

The discovery of *Miconia cordieri* brings to 15 the number of described species of *Miconia* sect. *Sagraea* known from the Morne Formon-Pic Macaya region of the Massif de la Hotte (see Ionta et al. 2012). Of these species, 10 are endemic to Hispaniola, and nine are endemic to the Massif de la Hotte.

Miconia cordieri Ionta & Judd, sp. nov. (**Figs. 1–2**). Type: HAITI. Departement du Sud: Massif de la Hotte, between Ville Formon and «Experiment Station» on Deron Plain, 1170–1190 m, 14 Nov 1989, *W. Judd 5859* (holotype: FLAS!; isotypes: FLAS!, EHH!).

Species haec ab *Miconia woodsii* (Judd & Skean) Ionta, Judd & Skean differ trichomatibus foliorum simplicibus, multicellulis, eglanduliferis, erectis, 0.1–0.3 mm longis, in veins et pagina abaxiali (non absentibus); trichomatibus caulium similaribus (non absentibus); trichomatibus hypanthii simplicibus, multicellulis, eglanduliferis, conicis, ± curvis, ad 0.3 mm longa et glanduliferis, elongatis, ad 0.6 mm longa (non utrinque absentibus); inflorescentiis ad 4.5 mm (non ad 8 mm) longas; ovario ½ infero (non ⅔ infero).

Shrub to 1.5 m tall. Indumentum of minute, multicellular, subsessile pseudopeltate globular-dendritic hairs with flattened and coalesced branches, multicellular, sessile to stalked elongate-dendritic hairs to 0.6 mm long, simple, erect, multiseriate hairs to 0.4 mm long, and broad based, curved, simple, multiseriate hairs from 0.1–0.2(–0.3) mm long. Young twigs to 2.2 mm wide, rounded-quadrangular in cross section, becoming terete with age, the young stems densely pubescent, with sessile to stalked, globular-dendritic hairs to 0.2mm long (occasionally to 0.3 mm long in interpetiolar regions), and scattered, simple, erect, multiseriate hairs to 0.4 mm long, the stems becoming glabrous with age; internodes 0.6–6.5 cm long. Leaves with petiole 1.5–9.3 mm long, ± rounded-triangulate, with hairs similar to those of the stem, elongate-dendritic hairs to 0.6 mm long often present adaxially, the petiole hairs persistent; blade 1.3–5.7 cm long, 0.7–2.7 cm wide, leaf pairs occasionally slightly to moderately anisophyllous, the blades elliptic, falcate, with discrete areas bounded by adjacent tertiary and quaternary veins adaxially convex, thus the leaves often bullate, the blade coriaceous, the apex acute, ± straight to slightly acuminate, culminating with a small, blunt mucro, the base ± symmetric, obtuse to rounded to slightly cordate, the margin plane, serrulate; largest teeth to ca. 0.2 mm, hairs on teeth incurved, to ca. 0.5 mm long; venation acrodromous, basal, with prominent midvein and 4 secondary veins, 2 conspicuous secondary veins positioned 1.1–4 mm from margin, and 2 inconspicuous secondary veins 0.1–0.4 mm from margin, numerous percurrent tertiary veins oriented sub-perpendicular to midvein and 0.9–3 mm apart, percurrent quaternary veins common, the higher order veins orthogonal-reticulate; adaxial surface glossy green (dark maroon when dried), initially with scattered minute, subsessile, pseudopeltate globular-dendritic hairs with flattened and coalesced branches, but these soon shed, elongate dendritic hairs (to 0.6 mm long) common at midvein particularly towards the leaf base and scattered on secondary and tertiary veins, and with broad-based, curved, simple, multiseriate hairs from 0.1–0.2 (–0.3) mm long, clustered in groups of one to six in the center of convex areas bounded by tertiary and percurrent quaternary veins, the midvein, major secondary and tertiary veins strongly to only slightly impressed, the percurrent quaternary veins moderately to slightly im-

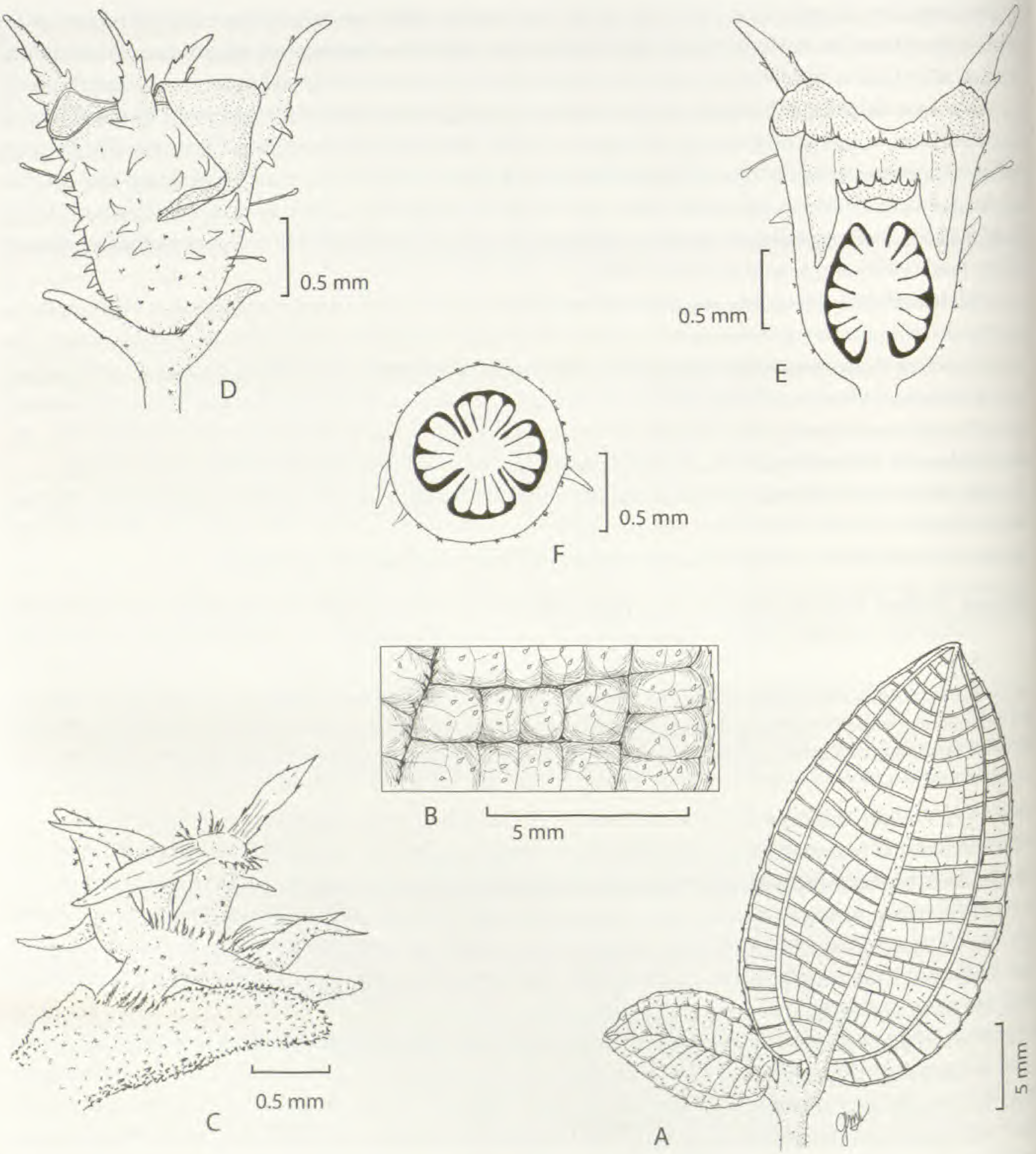

Fig. 1. ***Miconia cordieri*****. A. Abaxial and adaxial leaves. B. Detail of adaxial leaf surface. C. Inflorescence, flowers removed. D. Hypanthium, with one petal. E. Flower, longitudinal section. F. Ovary, cross-section.**

pressed, the surface smooth; the abaxial surface pale green (brownish-green when dry), with scattered, simple, erect, multiseriate hairs to 0.3 mm long on midvein, secondary to quaternary veins, and even on lamina, where they originate from veinlets, and minute, scattered subsessile, pseudopeltate hairs with fused, flattened branches, and sessile to short-stalked dendritic hairs to 0.1 mm long restricted to quaternary and higher order veins, the midvein strongly raised, the major secondary and tertiary veins moderately raised, and the percurrent quaternary veins slightly raised, the higher order veins ± flat. Inflorescences axillary, in one or both axils of leafy nodes, occasionally more than one inflorescence per axil; glomerate cymes with up to 5 flowers, lacking major branch-pairs, ca. 4.5 mm long, 3 mm wide, inflorescence branch segments to 0.9 mm, the ultimate

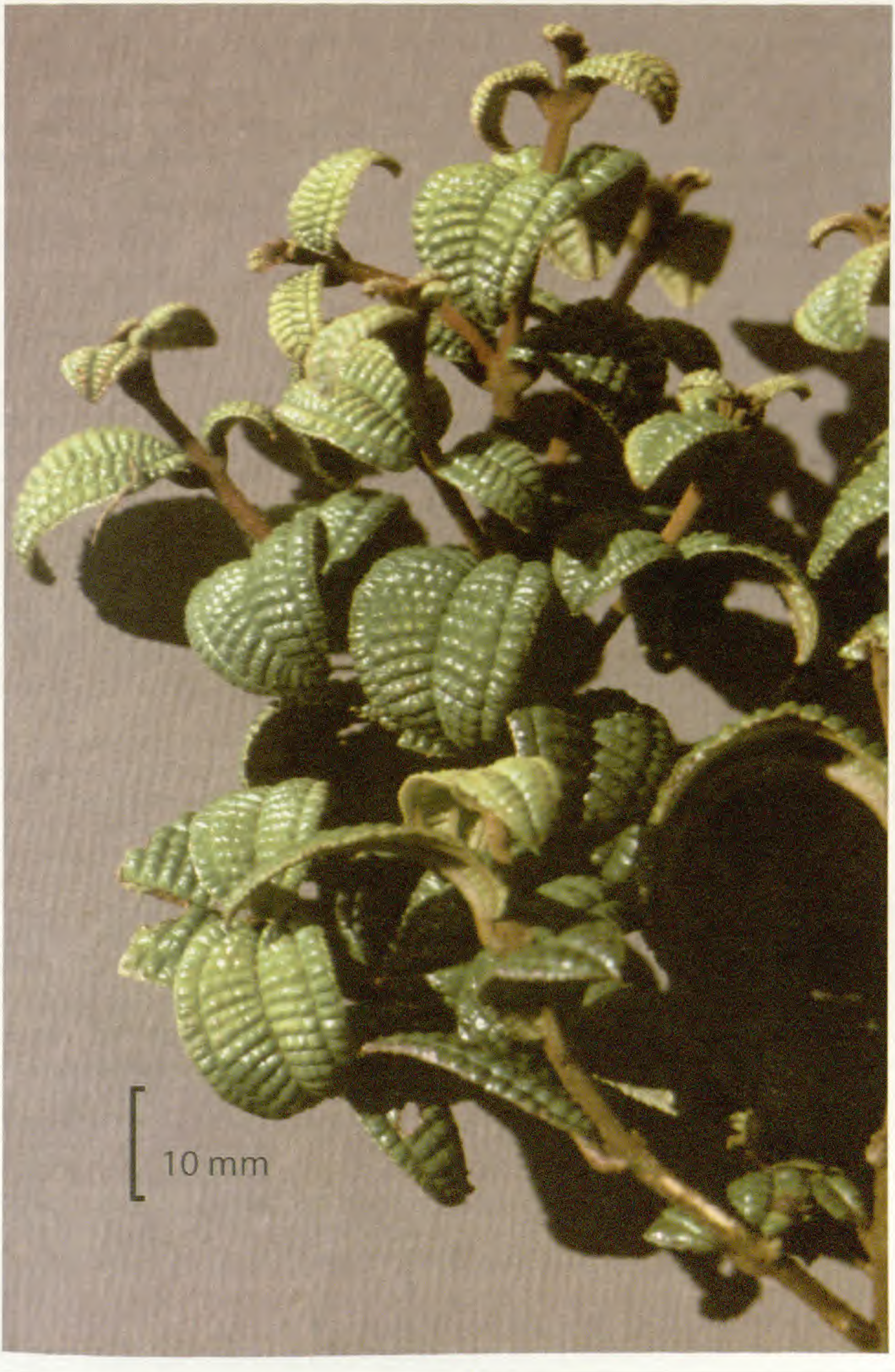

Fig. 2. *Miconia cordieri*. Branch, showing curved and strongly bullate leaves. From the holotype.

branches (pseudopedicels) to 0.5 mm long, inflorescence branches sparsely pubescent with minute globular-dendritic hairs and occasional, simple, erect, multiseriate hairs to 0.4 mm long; peduncle to 1.2 mm long, with similar indumentum, occasionally with an additional pair of bracts mid-peduncle, the mid-peduncle bracts early deciduous, narrowly triangular, to 1.5 mm long, 0.5 mm wide, the mid-peduncle bracts and subtending peduncle segment densely pubescent, with globular dendritic hairs similar to stem hairs; each inflorescence branch associated with a pair of persistent, narrowly triangular, linear bracts, 0.6–1 mm long, 0.3–0.5 mm wide, the bracts with globular-dendritic hairs similar to those of inflorescence branches abaxially and glabrous adaxially, and with sparse elongate-dendritic hairs to 0.3 mm long along nodal region between bract-pairs; each flower subtended by 2 persistent, narrowly triangular to linear bracteoles to 1 mm long, ca. 0.3 mm wide, with sparse hairs similar to those of inflorescence branches abaxially, glabrous adaxially, the apices acute. Flowers in dichasia, pedicels absent to 0.1 mm long. Hypanthium ± cylindrical, slightly flaring distally, 1.5–1.6 mm long, free portion ca. 1 mm long, the outer surface with scattered sessile to sub-sessile, globular-stellate hairs, scattered, minute globular to elliptic dark brown glands, simple, erect, multiseriate gland-headed hairs to 0.6 mm long, and simple, erect, stout conical hairs to 0.3 mm long, the inner surface glabrous. Calyx lobes 4, at anthesis 0.3–0.4 mm long, 1.1–1.3 mm wide, broadly triangular to rounded, the outer surface with hairs similar to hypanthium, the inner surface glabrous, the apex rounded to slightly acuminate, the margin entire to slightly erose; calyx teeth 4, 0.9–1.2 mm long, 0.15–0.2 mm wide, narrowly triangular with a ± terete distal portion, with an acute apex, hairs similar to those of hypanthium; the calyx tube ca. 0.1 mm long, inner surface glabrous, the lower rim appearing scalloped, with 8 low triangular projections corresponding to the insertion points of the stamens, and ringed with a fringe of inwardly-oriented hairs to 0.1 mm long. Petals 4, ca. 2 mm long, 0.4–0.5 mm wide, narrowly triangular, glabrous, the apex acute, slightly cupped, with or without a minute abaxial projection, the margin entire. Stamens 8, not seen. Ovary 4-loculate, ½ inferior, ovoid to narrowly ovoid, 1.2–1.4 mm long, 1.1–1.2 mm wide, with cylindrical apical collar encircling style, 8-lobed and distinctly ridged, with a crown of fine hairs to 0.1 mm long at the lobe apices; style and stigma not seen. Placentation axile; ovules numerous. Fruits not seen, presumably globose, blue berries.

Distribution and Ecology.—*Miconia cordieri* is endemic to Bwa Formon and Bwa Deron, on the high plateau with karstic hills south of Morne Formon in the Massif de la Hotte, growing at 950–1200 m. The two collections of this rare species were found growing in disturbed moist broadleaved forests on limestone.

Phenology.—The flowering period is poorly known and has been documented only in November.

Etymology.—The specific epithet refers to Dan and Tia Cordier, in acknowledgment of their important logistical assistance during W. S. Judd's 1984 fieldwork in the Massif de la Hotte, which resulted in the first collection of this species. Without their critical support, this fieldtrip and the subsequent trip to the same region by J.D. Skean, Jr. (then a graduate student working under the direction of W. S. Judd) would not have been possible. These two trips resulted in the discovery of 12 angiosperm species (and one subspecies) new to science (see Guerrero et al. 2004; Judd 1986b, c; Judd & Skean 1987a, b; 1993; Judd et al. 2008; Skean 1993, 2000; Skean & Judd 1986, 1988a, b) and facilitated the documentation of the diverse flora of this region (Judd 1987).

Additional Specimen Examined: **HAITI. Departement du Sud:** Macaya Biosphere Reserve, Massif de la Hotte, Bois Formon, S of village of Formon, S of Morne Formon, 950–1040 m, 23 Jan 1984, *W. Judd & D. Dod 3469* (FLAS, EHH, NY).

ACKNOWLEDGMENTS

This research was supported, in part, by National Science Foundation Grant BSR-0818399. The staff of the University of Florida Herbarium (FLAS) is gratefully acknowledged, especially Norris Williams, Kent Perkins and Trudy Lindler, for their help in processing specimen loans. Thanks also to the staff of the Electron Microscopy & Bioimaging Laboratory at the Interdisciplinary Center for Biotechnology Research, University of Florida. We thank Charles A. Woods, who organized (and supported, through his grants) the fieldtrips to the Massif de la Hotte in 1984 and 1989 during which the specimens of *Miconia cordieri* were collected. In addition, Paul Paryski, Sonny Parafina, Roy Voss, and Genness McBride provided field assistance on the 1989 trip, and Donald Dod assisted in fieldwork in 1984. Finally, we thank Darin Penneys and Taylor Sultan Quedensley for their helpful comments.

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A NEW SPECIES OF *VACHELLIA* (FABACEAE: MIMOSOIDEAE) FROM HAITI

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ABSTRACT

Vachellia koltermanii R. García, M. Mejía, Ebinger, & Seigler, a species from Département Ouest, Haiti, is described, illustrated, and compared to related species from Haiti and the Dominican Republic.

Key Words: Haiti, Mimosoideae, new species, *Vachellia koltermanii*

RESUMEN

Vachellia koltermanii R. García, M. Mejía, J. Ebinger, & D. Seigler, es una especie que se puede encontrar en el Departamento de Ouest, Haiti, de donde ha sido descrita, ilustrada y comparada con especies afines de Haiti y de la Republica Dominicana.

During the course of field work in Département Ouest, Haiti, shrubs of a previously undescribed species were collected. Most closely related to four other species of the genus *Vachellia* from the Dominican Republic (Clarke et al. 2009; Seigler et al. submitted), *V. barahonensis* (Urban & Ekman in Urban) Seigler & Ebinger, *V. cucuyo* (Barneby & Zanoni) Seigler & Ebinger, *V. oviedoensis* (R. García & M. Mejia) Seigler & Ebinger, and *V. azuana* R. García, T. Clase, Ebinger, & Seigler, ined., and one from Haiti, *V. caurina* (Barneby & Zanoni) Seigler & Ebinger, this new species occurs in the central part of Haiti. This taxon seems most closely related to *V. barahonensis*, but it is clearly distinctive and is proposed as a new species.

Vachellia koltermanii R. García, M. Mejía, Ebinger, & Seigler, sp. nov. (**Fig. 1**). Type: HAITI. Ouest: 13 km al norte de Croix Bouquets, en la carretera, a Mirabelais en un farallón al borde de la carretera con vegetación arbustiva, secondaria con *Exostema*, *Alvaradoa*, and *Croton*, 5 Apr 1998, *R. García, M. Mejia, and D. Kolterman 6921* (holotype: JBSD; isotypes: EHH, EIU, ILL).

Shrub to 4 m tall; bark unknown; twigs dark gray to dark reddish-brown, terete, not flexuous, glabrous to minutely puberulent; short shoots, 0.5–1.3 mm long, present above the stipular spines; prickles absent. **Leaves** alternate, also clustered on short shoots, 2.5–15.0 mm long; stipular spines light reddish-brown, becoming gray with age, symmetrical, terete, straight, not inflated, 1–5 × 0.3–0.7 mm near the base, glabrous to minutely puberulent; petiole adaxially grooved, 1.0–2.3 mm long, glabrous to minutely puberulent; petiolar gland solitary, located just below the pinna pair, columnar, 0.2–0.7 mm long, apex circular, 0.2–0.6 mm across, depressed, glabrous; rachis adaxially grooved, 0–13.5 mm long, minutely puberulent, lacking glands between the pinna pairs; pinnae (commonly 1 pair of pinnae on leaves from the short shoots) 2 to 6 pairs per leaf, 6–15 mm long, 2–6 mm between pinna pairs; paraphyllidia absent; petiolules 0.2–0.6 mm long; leaflets 12 to 32 pairs per pinna, opposite, 0.2–0.5 mm between leaflets, linear, 1.8–3.5 × 0.5–0.8 mm, lightly puberulent and with scattered minute glands, lateral veins not obvious, 1 vein from the base, base oblique, margins entire, apex obtuse; midvein central. **Inflorescence** a densely-flowered globose head, 6–9 mm across, probably solitary from the short shoots; peduncles 3–6 × 0.2–0.5 mm, puberulent; receptacle slightly enlarged; involucre 4 to 5-lobed, located near the base of the head, persistent; floral bracts spatulate, 0.3–0.6 mm long, sparsely puberulent, persistent. **Flowers** sessile, yellow; calyx 5-lobed, 0.4–0.7 mm long, glabrous; corolla 5-lobed, 1.6–2.3

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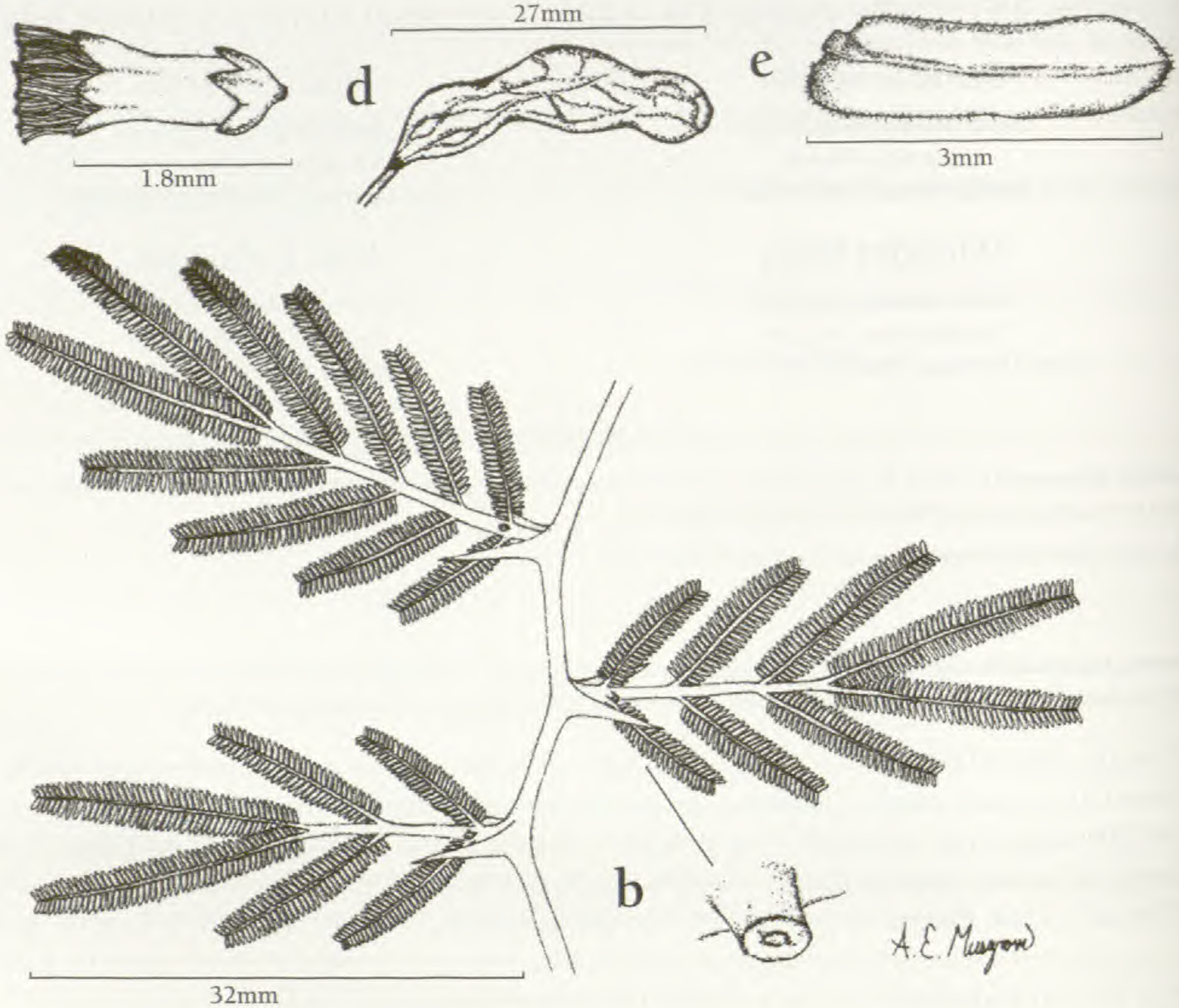

Fig. 1. *Vachellia koltermanii* R. García, M. Mejía, Ebinger, & Seigler. a. Section of bipinnately compound leaf with pinnae, leaflets. b. petiolar gland. c. partially reconstructed flower d. fruit. e. leaflet (adaxial surface). *R. García, M. Mejía, and D. Kolterman 6921.*

mm long, lightly puberulent, lobes one-quarter the length of the corolla; stamens 17–26; stamen filaments 3.0–4.0 mm long, distinct; ovary lightly pubescent, stipe absent to 0.3 mm long. **Fruits** oblong, 23–35 × 7–10 mm, slightly curved, nearly terete in cross section, not constricted between the seeds, coriaceous, not striate but wrinkled, glabrous, eglandular, indehiscent, dark reddish-brown to black; stipe 0.3–0.7 mm long; apex obtuse, not beaked. **Seeds** unknown.

Some of these data were obtained from a mass of spider-webs attached to one of the specimens (ILL) in which detritus including a few leaflets and peduncles with an involucre and floral bracts attached to the receptacle, and a few *Vachellia* flowers were imbedded.

Flowers.—May–July.

Chromosome number.—Not determined.

Distribution.—Dry thorn-scrub vegetation in Département Ouest, Haiti. This species occurs at low and intermediate elevations (to 400 m), where there is a definite dry season.

Representative specimens: Rare species known only from the type collection.

Etymology.—Named after Duane Kolterman, Herbario, Universidad de Puerto Rico, Mayagüez, one of the collectors and a student of rare and endangered species of the Greater Antilles.

KEY TO SPECIES OF *VACHELLIA* FROM THE DOMINICAN REPUBLIC AND HAITI

a. Leaves mostly with 2 or more pairs of pinnae (some species with an occasional leaf with only one pair of pinnae).
  b. Leaves mostly with 11 or more pairs of pinnae; short shoots absent ______ **Vachellia macracantha**
  b. Leaves with 10 or fewer pairs of pinnae; most species with a short shoot common just above many of the pairs of stipular spines.
    c. Legumes inflated, nearly terete in cross section, seeds in two rows (biseriate) or irregularly arranged ______ **Vachellia farnesiana**
    c. Legumes not inflated, mostly flat in cross section, seeds in a single row.
      d. Legumes less than 60 mm long, not constricted between seeds.
        e. Mostly two pairs of pinnae per leaf; leaflets 0.6–2.0 mm wide, glabrous, lateral veins obvious ______ **Vachellia cucuyo**
        e. Pinnae 2 to 6 pairs; leaflets 0.5–0.8 mm, lightly puberulent, lateral veins not obvious ______ **Vachellia koltermanii**
      d. Fruit mostly more than 70 mm long, constricted between the seeds.
        f. Stipular spines to 100 mm long; involucre located near the middle of the peduncle ______ **Vachellia nilotica**
        f. Stipular spines less than 50 mm long; involucre located at the base of the globose head ______ **Vachellia tortuosa**
a. Leaves consistently with 1 pair of pinnae.
  g. Sprawling shrub to 1 m tall; leaflets finely puberulent (Haiti) ______ **Vachellia caurina**
  g. Erect shrub or small tree; leaflets glabrous or nearly so.
    h. Leaflets mostly one (rarely 2) pairs per pinna ______ **Vachellia oviedoensis**
    h. Leaflets consistently 2 or more pairs per pinna.
      i. Leaflets 4 to11 pairs per pinna; petioles 0.1–0.5 mm long ______ **Vachellia barahonensis**
      i. Leaflets 2 to 4 pairs per pinna; petioles 0.7–5.0 mm long ______ **Vachellia azuana**

ACKNOWLEDGMENTS

The authors wish to thank Kanchi Gandhi for advice concerning questions of nomenclature and Scott Zona and an anonymous reviewer for helpful comments. Nonetheless, the views (and errors) in this manuscript are our own and do not necessarily reflect their judgments. We wish to acknowledge support by the National Science Foundation (NSF 04-15803) and the University of Illinois Research Board (1994, 2001). We wish to acknowledge support by the National Science Foundation (NSF DEB 04-15803) and by the American Philosophical Society (1992). We wish to thank Alexa E. Musgrove for the preparation of drawings.

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Clarke, H.D., D.S. Seigler, and J.E. Ebinger. 2009. Taxonomic revision of the *Vachellia acuifera* species group (Fabaceae: Mimosoideae) in the Caribbean. Syst. Bot. 34:84–101.

Seigler, D.S., R. García, T. Clase, and J.E. Ebinger. Submitted. A new species of *Vachellia* (Fabaceae: Mimosoideae) from the Dominican Republic. Novon.

BOOK REVIEW

David Small and Ella May T. Wulff. 2008. **Gardening with Hardy Heathers.** (ISBN 13: 9780881927825, hbk.). Timber Press, Inc., The Haseltine Building, 133 S.W. Second Avenue, Suite 450, Portland, Oregon 97204-3527, U.S.A. (**Orders:** www.timberpress.com, 800-327-5680). $39.95, 296 pp., 1 line drawing, 214 color photos, 17 maps, 2 charts, 7"× 10".

The authors ask the question, "Why Grow Heathers?" in the opening chapter. The answer is convincingly supplied in following chapters. The reader is drawn into the fascinating and diverse world of the large group of plants collectively called heathers. Heathers occupy several genera, including *Calluna, Erica, Daboecia,* and *Andromeda.*

This book offers extensive information on care and cultivation of heathers, as well as propagation methods, guidance on designing a heather garden, and uses of companion plants. The authors share their knowledge of the popularity of heather breeding while clarifying the muddy waters of heather nomenclature.

Many of the heathers originated in the Northern Hemisphere. Their preferred climate is temperate with annual rainfall over 40 inches. Many types are found at altitudes over 1,000 feet in elevation and in alpine environments. Because heathers thrive in areas with poor soils, near coastal regions, in windy locations, and in boggy soils they are one of the most adaptable groups of plants, useful in a wide variety of garden applications. Heathers are most readily associated with two types of ecosystems: the heaths and moorlands in Western Europe. Here they grow mixed with grasses, forbs, other shrubs, and occasionally trees to create essential habitat for many animals, especially birds.

Humans have also found many uses for heathers: as material for making rope, baskets, brooms, bedding, fences, animal fodder, as well as ingredients in traditional medicines and dyes. One of the first uses of heather was as a fuel source. These plants have also been used for building material, primarily as the source of thatch for roofing. However, sod houses (called turves in Scandinavia) were widely constructed from heathers. Our modern word "turf is derived from "turve."

Care and cultivation of heathers are discussed in detail. While heathers are found in harsh and marginal environments, the perception that they require no special care when cultivated is erroneous. Heathers can be successfully grown in hot summer climates if afternoon shade is provided. Likewise, they require winter protection when grown in zones colder than their rated tolerance. Proper soil conditions are also essential for growing heathers. A soil that is acidic, high in organic matter, well draining yet moisture retentive is desirable. Heathers cannot survive if planted in clay.

The authors describe pruning as the least understood aspect of heather culture. These plants benefit from annual pruning that removes spent flower stems. Pests that harm heathers are also discussed. Rabbits, hares, and other rodents can cause damage, though heathers are not preferred by deer. Other pests include the heather beetle, red spider mite, vine weevil, and parasitic nematodes.

In the design discussion, careful planning for site preparation is emphasized. Many heather-themed gardens strive to express a natural or informal effect, but heathers are well suited to frequent pruning, so they are also used in formal knot gardens. While heathers are generally thought of as low-growing shrubs or ground covers, the authors provide information on taller varieties (tree heaths) which can add height to garden plantings.

The book includes photographs and maps of species ranges. Methods for production of cut flowers and techniques for drying heathers are described. The last chapter, "Heathers for Special Uses" is an excellent reference for growers, providing lists of heathers with similar traits and care needs.

—Jackie Peel, Volunteer,
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CALATHEA RHIZANTHOIDES AND *C. PEREGRINA* (MARANTACEAE), NEW SPECIES ENDEMIC TO PANAMA

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ABSTRACT

Calathea rhizanthoides H. Kenn., sp. nov. and **C. peregrina** H. Kenn., sp. nov., both endemic to Panamá, are described as new for inclusion in Flora Mesoamericana. *Calathea rhizanthoides* is characterized by the single leaf per shoot and the inflorescence usually borne on a separate, leafless, shoot directly from the rhizome. It differs from *C. verecunda* H. Kenn. by the broader leaf blades (9.1–16.5 vs. 4–8 cm), the bracts with rounded vs. acute to acuminate apices and from *C. cleistantha* Standl. by the single vs. 2–4(–9) leaves per shoot. *Calathea peregrina* differs from the closely related *C. portobelensis* H. Kenn. in the narrower angle of divergence of the lateral veins from the midrib (38°–47° vs. 46°–62°) and the more widely spaced lateral veins (11–14 vs. 17–22 per 3 cm).

RESUMEN

Calathea rhizanthoides H. Kenn., sp. nov. y **C. peregrina** H. Kenn., sp. nov., ambas endémicas de Panamá, son descritas como nuevas para su inclusión en Flora Mesoamericana. *Calathea rhizanthoides* se caracteriza por tener solo una hoja por brote y la inflorescencia en un brote aparte, sin hojas, que sale directamente del rizoma. Se diferencia de *C. verecunda* H. Kenn. por sus láminas foliares más anchas (9.1–16.5 vs. 4–8 cm), las brácteas con el ápice redondeado vs. agudo o acuminado, y de *C. cleistantha* Standl. por tener una sola hoja en vez de 2–4(–9) hojas por brote. *Calathea peregrina* difiere de la estrechamente relacionada *C. portobelensis* H. Kenn. por el ángulo de divergencia de las venas laterales del nervio medio más angosto (38°–47° vs. 46°–62°) y venas laterales más distanciadas (11–14 vs. 17–22 por 3 cm).

In the Flora of Panama (Woodson & Schery 1945), a total of 23 species of Marantaceae were listed with 14 in the genus *Calathea*. By 1972, Dressler (1972: 184) reported 35 species and recently Kennedy (2011: 201) reported a total of 59 species of Marantaceae from Panama. Currently 65 species of Marantaceae (ca. 182% increase from the 1945 Flora of Panama treatment) are recognized from Panama of which 47 are in the genus *Calathea*. Seventeen species are endemic, including the two described herein. *Calathea*, which is restricted to the Neotropics, is the largest genus within the Marantaceae with approximately 286 species, comprising roughly 57% of the Neotropical Marantaceae species. The majority of *Calathea* species are South American with Brazil (at least 95) and Ecuador (at least 66) being the most diverse. For the whole of Central America, including Mexico, there are but 75 currently recognized species of *Calathea*.

TAXONOMIC TREATMENT

Calathea rhizanthoides H. Kenn., sp. nov. (**Fig. 1**). Type: PANAMA. Panamá: Km 16 on the road to Cartí (El Llano-Cartí road), wet forest, ca. 350 m, 23 Mar 1973, *H. Kennedy & R.L. Dressler 2908* (holotype: PMA; isotypes: MEXU, MO, UCR).

Haec species a *Calathea verecunda*. foliis latioribus (9.1—16.5 vs. 4—8 cm) atque bracteis viridibus (vs. purpureis) apice rotundatis (vs. acutis vel acuminatis), a *C. cleistantha* foliis plerumque minoribus (17—30 × 9.1—16.5 vs. 25—54 × 12—22), folio in quoque surculo solitario (vs. foliis 2 ad 9) atque bracteolis claviculatis praesentibus distinguitur.

Plants rhizomatous, perennial herbs, 36–55 cm high; the inflorescence may terminate a single-leaved shoot but more commonly is borne on a leafless shoot directly from the rhizome; cataphylls herbaceous, narrowly ovate, obtuse, apiculate, minutely puberulent along margins, innermost cataphyll 6–15 cm. **Leaves** 2–5 from a single rhizome, each leaf borne separately from the rhizome, or a leaf may subsequetly develope in the axil of the cataphyll subtending an inflorescence; leaf sheath not auriculate (apical margins of sheath not extended above junction of sheath with petiole), green, subglabrous except at very base and onto node sericeous, (1–)

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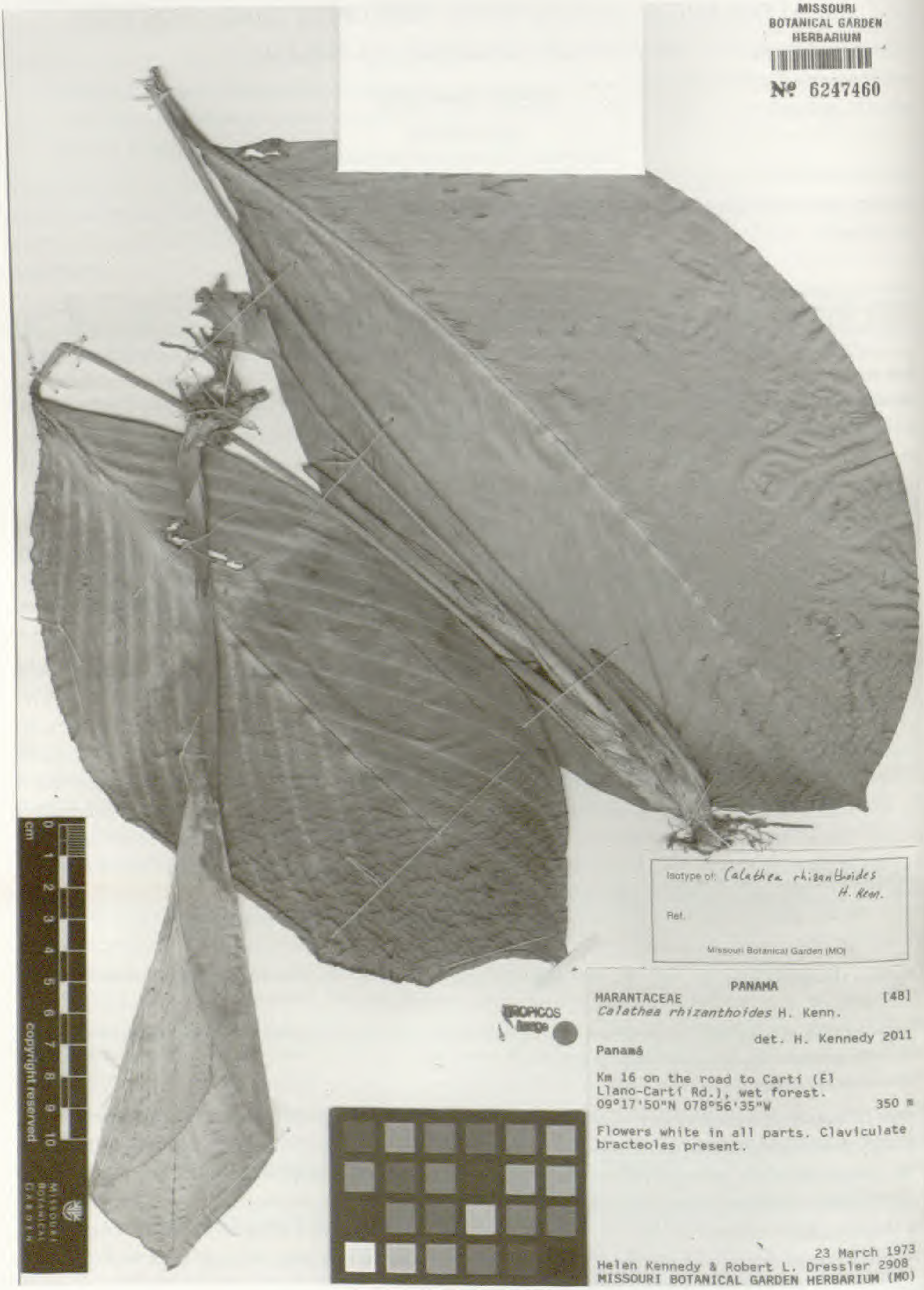

MISSOURI
BOTANICAL GARDEN
HERBARIUM
№ 6247460
Isotype of: Calathea rhizanthoides
H. Kenn.
Ref.
Missouri Botanical Garden (MO)
PANAMA
MARANTACEAE [48]
Calathea rhizanthoides H. Kenn.
det. H. Kennedy 2011
Panamá
Km 16 on the road to Cartí (El
Llano-Cartí Rd.), wet forest.
09°17'50"N 078°56'35"W 350 m
Flowers white in all parts. Claviculate
bracteoles present.
23 March 1973
Helen Kennedy & Robert L. Dressler 2908
MISSOURI BOTANICAL GARDEN HERBARIUM (MO)
TROPICOS
cm
0 1 2 3 4 5 6 7 8 9 10
copyright reserved
MISSOURI BOTANICAL GARDEN

Fig. 1. *Calathea rhizanthoides* H. Kenn. Isotype (*Kennedy & Dressler 2908*, MO). Photo provided by Missouri Botanical Garden.

2.8–9.5(–14) cm; petiole bearing a distinct groove adaxially, green, scattered tomentose, hairs more concentrated apically, abaxially and in adaxial groove, 7–25.5 cm; pulvinus ellipsoid in cross-section, olive-green, densely tomentose in a band adaxially, sides glabrous, abaxially sparsely pubescent, 0.6–1.2 cm; leaf blade elliptic to obovate, apex obtuse to rounded with an acumen, base attenuate to cuneate, 17–30 × 9.1–16.5 cm in basal leaves, (length:width ratios 1.67–2.12:1), lateral veins 13–18 per 3 cm, cross veinlets 20–25 per 5 mm (veins measured at midpoint of each side of blade, ruler at right angles to veins), vein angles from midrib 28°–39°, measured at midpoint of blade, the adaxial surface green, glabrous, midrib densely minutely appressed tomentose centrally, hairs golden brown, 0.2 mm, the abaxial surface minutely pubescent along veins (20× magnif.) near midrib, toward margin pubescence only on major veins, midrib sparsely minutely appressed tomentose, hairs golden brown, ca. 0.1 mm. **Inflorescence** terminal, 1 per shoot, usually borne on a separate leafless shoot, imbricate, obovoid, occasionally ellipsoid, 2.4–3.2 × 1.1–1.8 cm; peduncle green, very sparsely minutely puberulent (20× magnif.), hairs colorless, 0.1–0.25 mm, 11.5–24(–29.5) cm. **Bracts** 5–9, spirally arranged, herbaceous, lowermost one transversely broadly elliptic, apex rounded with acumen to 0.5 cm, second broadly elliptic, upper ones obovate, apex rounded with short acumen, apex very slightly spreading, 1.6–2 × 1.5–2.3 cm, each bract subtending up to 5 or more flower pairs, abaxial surface of bracts light green, minutely tomentose, hairs colorless, 0.5 mm, hairs more dense along margin in apical third, adaxial surface minutely tomentose in apical half; bicarinate prophyll membranaceous, elliptic, apex obtuse to rounded, minutely sparsely pilose at apex, including area between the carina, ca. 1.5 × 1 cm, 0.6 cm wide, carina to carina; secondary bract membranaceous, elliptic, ca. 1.6 × 0.7 cm; bracteoles 3 per flower pair, 1 medial, claviculate, 1.3–1.55 cm, 2 lateral, membraneous, channeled, narrowly ovate-triangular, acute, ca. 1.3 × 0.25 cm. **Flowers** open spontaneously, white throughout. **Sepals** membraneous, narrowly elliptical, acute, glabrous, ca. 13 × 3 mm. **Corolla** tube glabrous, ca. 23 mm; corolla lobes subequal, elliptic, obtuse, glabrous except for a minute tuft of hairs at the very tip, hairs 0.2 mm, 9–10 × ca. 4 mm. **Staminodes** 3; outer staminode ellipsoid, clawed at base, cupped, ca. 8 mm; callose staminode petaloid apically, ca. 9 mm; anther 1.5–2 mm; ovary smooth, glabrous, ca. 2.5 × 1.5 mm. **Capsule** unknown.

Additional specimens examined: **PANAMÁ. San Blas:** Cerro Obu, assoc: *Wettinia, Calyptrogyne, Pholldostachys mooreana, Prestoea & Bonofousia sanano*, 400–500 m, 25 Jun 1986, *G. de Nevers et al. 8073* (MO); trail to Cerro Obu (Habu of maps) from Río Urgandi (Río Sidra), assoc: *Bonofousia undulata*, 100–300 m, 9°23'N, 78°48'W, 25 Jun 1986, *G. de Nevers et al. 8020 A* (MO).

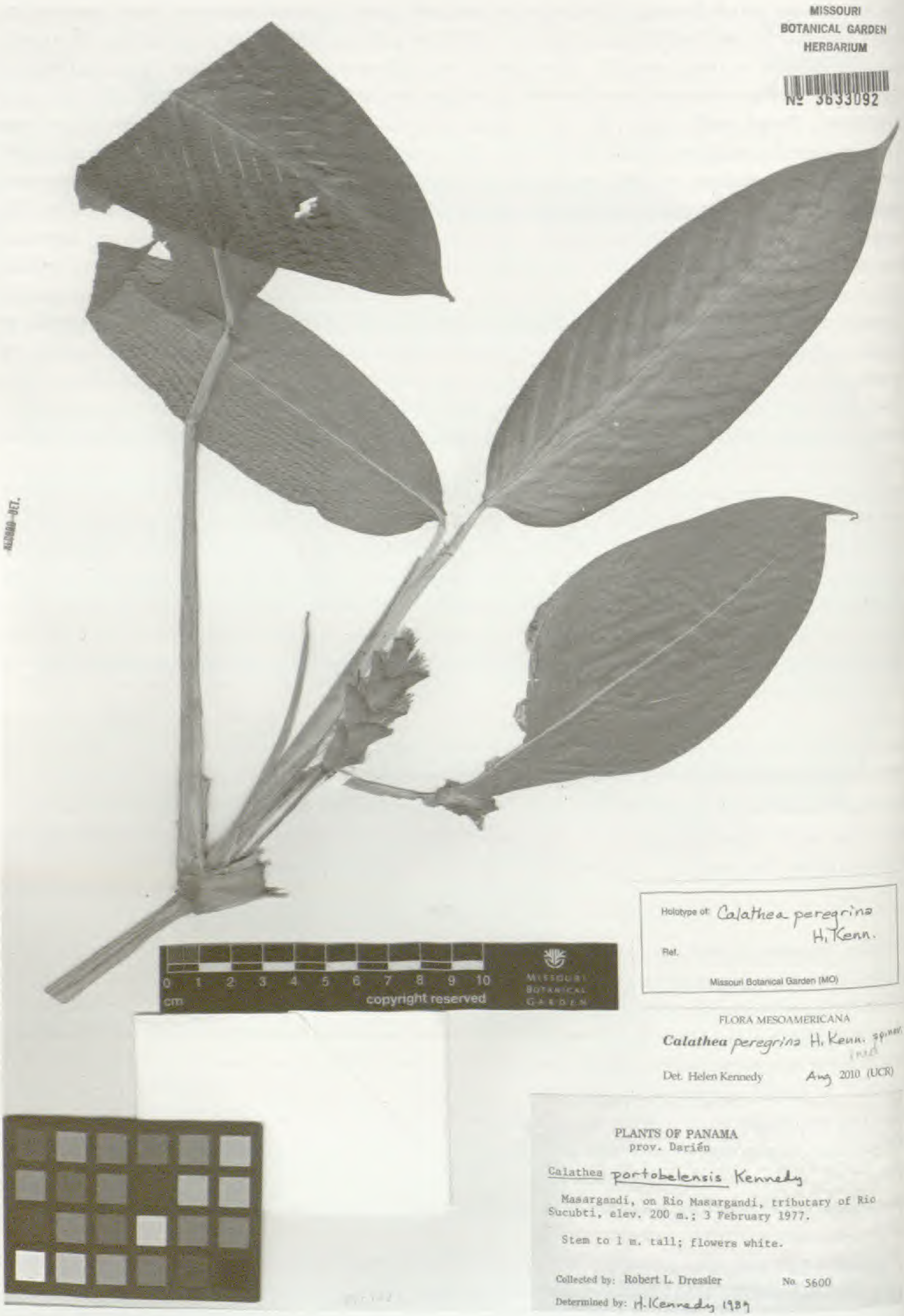
Distribution and habitat.—*Calathea rhizanthoides* is endemic to Panamá. It is known from only two collections, one on the Pacific slope in Panama Prov. and the other from a somewhat higher elevation, Cerro Obu, just into Comarca de San Blas but close to the border with Panamá Province, both in wet forest habitats.

DISCUSSION

Calathea rhizanthoides belongs to *Calathea* sect. *Breviscapus* Benth. in the broad sense. It is readily distinguished from other Panamanian species by the single leaf per aerial shoot, the elliptic to obovate leaf blade, the inflorescence of 5–8 bracts, usually borne on a separate leafless shoot, the presence of both membranous and claviculate bracteoles and the white flowers. In *C. verecunda*, the leaves are often borne singly and the inflorescences borne on separate, leafless shoots. However, *C. verecunda* differs in having narrower leaf blades, 4–8 vs. 9.1–16.5 cm; purple vs. green bracts with acute to acuminate vs. rounded apices and bracteoles 4, all membranous vs. 2 membranous and 1 claviculate. *Calathea cleistantha* also has inflorescences borne on separate shoots but has more numerous inflorescences, 2–4(–9) vs. 1, as well as larger leaves, 25–54 × 12–22 vs 17–30 × 9.1–16.5 cm, and lacks claviculate bracteoles. However, both *C. elegans* H. Kenn. and *C. robin-fosteri* H. Kenn. also have membranous as well as claviculate bracteoles but have narrowly elliptic leaves over 30 cm long vs. elliptic to obovate leaves 30 cm long or less.

Etymology.—The specific epithet, *rhizanthoides*, refers to the inflorescence borne on a separate shoot directly from the rhizome as in *Calathea rhizantha* K. Schum.

Calathea peregrina H. Kenn., sp. nov. (**Fig. 2**). TYPE: PANAMÁ. DARIEN: Río Masargandi, tributary of Río Sucubti, Masargandi, 200 m, 3 Feb 1977, *R.L. Dressler 5600* (HOLOTYPE: MO 3633092).


MISSOURI
BOTANICAL GARDEN
HERBARIUM
№ 3633092
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MISSOURI
BOTANICAL
GARDEN

Holotype of: *Calathea peregrina* H. Kenn.

Ref.

Missouri Botanical Garden (MO)

FLORA MESOAMERICANA

Calathea peregrina H. Kenn. sp. nov. ined.

Det. Helen Kennedy Aug 2010 (UCR)

PLANTS OF PANAMA
prov. Darién

Calathea portobelensis Kennedy

Masargandi, on Rio Masargandi, tributary of Rio Sucubti, elev. 200 m.; 3 February 1977.

Stem to 1 m. tall; flowers white.

Collected by: Robert L. Dressler No. 5600

Determined by: H. Kennedy 1989

FIG. 2. *Calathea peregrina* H. Kenn. Holotype (*Dressler 5600*, MO). Photo provided by Missouri Botanical Garden.

Haec species a *Calathea portobelensis* venis lateralibus dissitioribus (11 ad 14 vs. 17 ad 22 per 3 cm) angulum minorem (38°–47° vs. 46°–62°) cum costa plerumque formantibus atque vena minore inter venis lateralibus majoribus plerumque solitaria (vs. venis minoribus 3) distinguitur.

Plants rhizomatous, perennial herbs, ca. 1.3 m high; stem ca. 1 m, glabrous apically. **Leaves** 2 or more cauline, basal leaves present, details unknown; leaf sheath not auriculate when petiole present, auriculate (apical margins of sheath extended above junction of sheath with petiole), if petiole absent, green, densely tomentose apically, especially the auriculate portion and along margin in upper 1–2 cm, sides and back subglabrous to glabrous, basalmost 7–8 mm sericeous, 8.5–18 cm in cauline leaves; petiole green, when present, bearing a groove adaxially, sparsely tomentose just below pulvinus, glabrous basally, (0–)0.6–1.8 cm in cauline leaves; pulvinus elliptic in cross-section, densely tomentose in a band adaxially, the rest glabrous, hairs to 0.6 mm, 0.25–0.4 cm in cauline leaves; leaf blade herbaceous, elliptic, apex acuminate, base obtuse, shortly abruptly attenuate, 15.5–18.5 × 4.8–6.5 cm in cauline leaves (length:width ratios 2.45–3.3:1), lateral veins 11–14 per 3 cm, cross veinlets 33–40 per 5 mm (veins measured at midpoint of each side of blade, ruler at right angles to veins), vein angles from midrib 38°–47°, measured at midpoint of blade, adaxial surface green, glabrous except apical 2 cm of apex pilose along very margin and into acumen, midrib minutely appressed tomentose in center, hairs colorless 0.3–0.5 mm, abaxial surface light grey-green, minutely pilose along veins, hairs 0.1–0.25 mm, additionally a row of hairs is present along the margin between the hyaline margin and outermost marginal vein in the apical two thirds, midrib pilose throughout, hairs to 0.4 mm in acumen. **Inflorescence** terminal, 1 per shoot (a new shoot may develop in the axil of the leaf subtending the inflorescence), imbricate, ellipsoid, ca. 5 × 2.3 cm; peduncle green, glabrous, ca. 5 cm. **Bracts** ca. 8, spirally arranged, herbaceous, lowermost bract broadly transverse ovate, apex obtuse with acumen, upper ones broadly ovate, apex obtuse, margin not recurved, 1.3–1.8 × 1.2–2 cm, each bract subtending 6 or more flower pairs, abaxial surface green, very minutely pilose near margins and apex (30× magnification), hairs ca. 0.1 mm, central and basal portions glabrous, adaxial surface densely pilose apically; bicarinate prophyll membranaceous, elliptic, apex obtuse to rounded, glabrous or very sparsely pilose on sides at apex, 1.5–1.6 × 0.8–1 cm, 0.6–0.7 cm wide, carina to carina; secondary bract membranaceous, elliptic, apex obtuse to rounded, glabrous, ca. 1.6 × 0.8 cm; bracteoles 1 per flower pair, claviculate, medial, 1.7–1.9 cm. **Flowers** open spontaneously, white. **Sepals** membranous, elliptic, obtuse to 90°, glabrous, 1.6–1.8 × 4–5 mm. **Corolla** tube glabrous, ca. 22 mm; corolla lobes subequal, elliptic, glabrous, ca. 11–12 × 3.5–4.5 mm. **Staminodes** 3; outer staminode subrotund, apex rounded, ca. 9 × 8 mm; callose staminode spathulate, petaloid apically, apex rounded, ca. 9 mm; cucullate staminode ca. 5 mm; stamen with lateral petaloid appendage, ca. 1 mm wide, anther 2.5 mm; ovary glabrous, ca. 2.5 × 1.5 mm. **Capsule** unknown.

Distribution.—*Calathea peregrina* is known only from the type, collected near Masargandi, Darien Prov., in moist tropical forest.

DISCUSSION

Calathea peregrina belongs to *Calathea* section *Breviscapus* Benth. It is most closely related to *C. portobelensis*, both having basal and cauline leaves, the inflorescence borne on the leafy shoot, spirally arranged green bracts, claviculate bracteoles and white flowers. It differs from *C. portobelensis* in the narrower angle of divergence of the lateral veins from the midrib, 38°–47° vs. 46°–62°, the more widely spaced lateral veins, 11–14 vs. 17–22 per 3 cm, usually a single minor vein rather than 3 between the major lateral veins and a single claviculate bracteole vs. 2 lateral, membranous bracteoles in addition to a medial, claviculate bracteole per flower pair.

Etymology.—The specific epithet *peregrina*, meaning foreign, exotic or strange is in reference to the species turning up as the joker in the deck, something foreign or strange. It was only in going through a pile of *Calathea portobelensis* specimens to compare with another similar species, that the specimen of *C. peregrina* struck one as clearly the odd one out.

ACKNOWLEDGMENTS

The Missouri Botanical Garden provided support for my accommodations while working in the MO herbarium (organized, thanks to Olga Martha Montiel). The travel expenses for the trip to MO were provided by Fred

Ganders. I am very grateful to Gerrit and Jeany Davidse for their help in the MO herbarium, to Roy Gereau (MO) for the Latin diagnosis, to Barry Hammel and Helen Poulos for help with the Spanish resumen and to Charlotte Taylor and two anonymous reviewers for their helpful comments and corrections. The type scans were provided by the Missouri Botanical Garden.

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CALATHEA CAROLINEAE (MARANTACEAE), A NEW SPECIES ENDEMIC TO HONDURAS

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ABSTRACT

Calathea carolineae H. Kenn., sp. nov., known only from two collections in Parque Nacional Cusuco, Cortes Department, Honduras, is described as new for inclusion in Flora Mesoamericana. *Calathea carolineae* differs from *C. atropurpurea* Matuda and *C. matudae* H. Kenn. in lacking claviculate bracteoles and the non-recurved bract margins; and differs from *C. micans* (L. Mathieu) Körn. by the minutely pilose adaxial leaf surface and deciduous habit.

RESUMEN

Calathea carolineae H. Kenn., sp. nov., conocida solo de dos colecciones de Parque Nacional Cusuco, Departamento de Cortés, Honduras, es descrita como nueva para su inclusión en Flora Mesoamericana. Se diferencia de *C. atropurpurea* Matuda y *C. matudae* H. Kenn. por la ausencia de bractéolas claviculadas y los márgenes de las brácteas no recurvados; y de *C. micans* (L. Mathieu) Körn. por el envés de la lámina diminutamente piloso y hábito deciduo.

Currently 18 species of Marantaceae are recognized for Honduras, 10 in the genus *Calathea*, including the new species described herein. The related, *C. matudae* (Kennedy & Ganders 2011: 59), had been previously identified as *C. atropurpurea*, a species now recognized as endemic to western Mexico. Thus, the total number of species has only increased by one, but that species, *C. carolineae*, is the only Marantaceae species endemic to Honduras.

TAXONOMIC TREATMENT

Calathea carolineae H. Kenn., sp. nov. (**Fig. 1**). Type: HONDURAS. Cortés: W of San Pedro Sula, Sierra de Merendón, Parque Nacional Cusuco, El Cortecito Camp-site, valley bottom in montane rain forest, 1305 m, Grid ref. 0361758 1716496, 17 Jul 2008, *D. L. Kelly 12033* (holotype: BM; isotype: HEH)

Haec species a *Calathea atropurpurea* Matuda et *C. matudae* H. Kenn. bracteolis claviculatis absentibus atque bracteis marginibus non recurvatis, a *C. micans* (L. Mathieu) Körn. foliis adaxialiter minute pilosis atque habitu deciduo distinguitur.

Plants deciduous, rhizomatous, herbs, 40–60 cm. **Leaves** 3–5, basal; leaf sheath 11–18 cm, not auriculate, pilose; petiole 1.5–14 cm, bearing a groove adaxially, pilose along groove, becoming subglabrous basally but hairs more dense just above sheath; pulvinus 0.6–1.2 cm, densely tomentose in a narrow band adaxially, the rest glabrous; leaf blade 10–21 × 4.5–9 cm, thin, herbaceous, elliptic, asymmetric, ratio of larger to smaller side of blade 1.31–1.54:1, apex obtuse with acumen, acumen to 1 cm, slightly eccentric, base obtuse, shortly abruptly attenuate, lowermost the smallest, lenght:width ratios 1.96–2.74:1, 10–15 lateral veins per 3 cm, 17–19 cross veinlets per 5 mm (veins measured at midpoint of each side of blade); adaxial surface of blade green with scattered minute hairs, each borne on a slightly raised basal cluster of cells, hairs 0.1–0.2 mm, more dense in acumen, midrib lighter green, appressed tomentose, hairs 0.3–0.5 mm; abaxial surface of blade light green, glabrous except acumen sparsely tomentose, hairs 0.3–0.5 mm, midrib light yellow-green, glabrous except tomentose along sides in basal 1–2 cm. **Inflorescence** terminal, 1 per shoot, usually borne above the leaves, 2–2.2 × 1.5–1.7 cm, imbricate, turbinate to broadly ovoid; peduncle 40–56 cm, glabrous. **Bracts** 8–10, 1.2–1.4 × ca.0.8 cm, spirally arranged, herbaceous, broadly ovate to ovate, apex acuminate attenuate in lowermost, upper ones acute, apex not recurved; abaxial surface of bracts cream basally, green apically (fide *Kelly 12033*), densely

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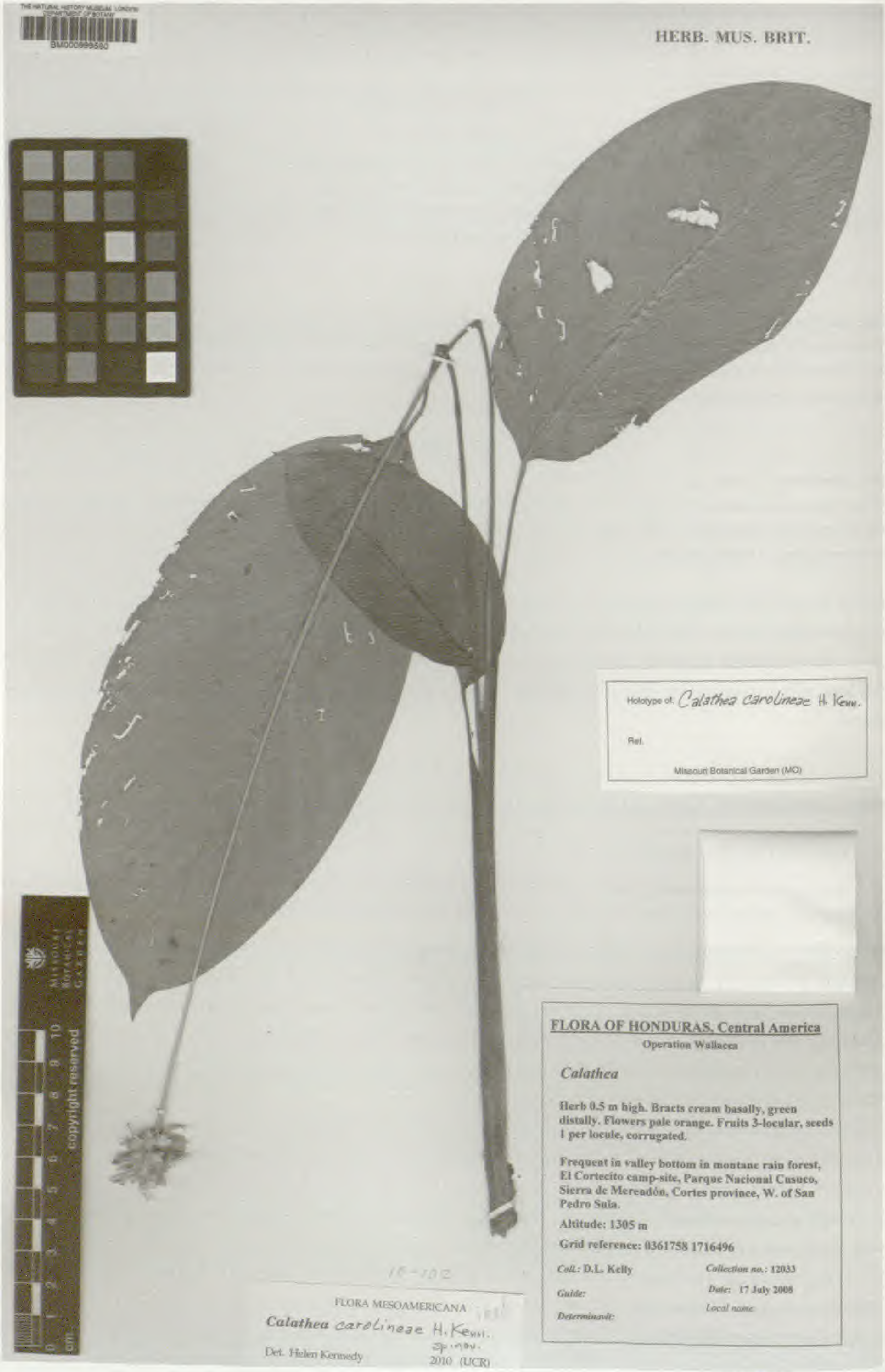
THE NATURAL HISTORY MUSEUM, LONDON
DEPARTMENT OF BOTANY
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HERB. MUS. BRIT.
Holotype of Calathea carolineae H. Kenn.
Ref.
Missouri Botanical Garden (MO)
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cm 0 1 2 3 4 5 6 7 8 9 10
FLORA OF HONDURAS, Central America
Operation Wallacea
Calathea
Herb 0.5 m high. Bracts cream basally, green distally. Flowers pale orange. Fruits 3-locular, seeds 1 per locule, corrugated.
Frequent in valley bottom in montane rain forest, El Cortecito camp-site, Parque Nacional Cusuco, Sierra de Merendón, Cortes province, W. of San Pedro Sula.
Altitude: 1305 m
Grid reference: 0361758 1716496
Coll.: D.L. Kelly
Collection no.: 12033
Guide:
Date: 17 July 2008
Local name:
Determinavit:
FLORA MESOAMERICANA
Calathea carolineae H. Kenn.
sp. nov.
Det. Helen Kennedy
2010 (UCR)

Fig. 1. *Calathea carolineae* H. Kenn. Holotype (*Kelly 12033*, BM). Photo provided by Missouri Botanical Garden

pilose, hairs 0.2–0.3 mm, less densely so centrally near base; adaxial surface sparsely minutely pilose apically; bicarinate prophyll 0.7–0.9 × 0.45–0.6 cm, ca. 0.35 cm wide, carina to carina, membranaceous, elliptic, apex obtuse, translucent cream-colored, glabrous; secondary bract ca. 0.75 × 0.4 cm, membranaceous, elliptic, apex obtuse, glabrous. **Flowers** pale orange (fide *Kelly 12033*). **Sepals** ca. 10–11 × 3 mm, membranous, narrowly elliptic, acute, glabrous. **Corolla** tube glabrous; corolla lobes ca. 7 × 3 mm, subequal, elliptic, apex obtuse, margins inrolled, appearing acute, light orange, glabrous. **Ovary** ca. 1.5 × 1.5 mm, smooth, glabrous. **Capsule** obpyramidal, glabrous, crowned by a persistent calyx.

Additional specimens examined: **HONDURAS. Cortés:** W of San Pedro Sula, Sierra de Omoa, Parque Nacional Cusuco, near river at El Cortecito Camp, primary forest, UTM 0361 1716, 14 Jul 2006, *R. Fritch 14* (BM).

Distribution.—*Calathea carolineae* is known from two collections near El Cortecito Camp in Parque Nacional Cusuco.

Discussion.—*Calathea carolineae* belongs to *Calathea* section *Breviscapus*. It is most closely related to *C. atropurpurea* Matuda and *C. matudae* H. Kenn. but is readily distinguished from those in lacking claviculate bracteoles. It is further distinguished from *C. matudae* by the glabrous vs. tomentose abaxial leaf surface. In dried specimens, the bract tips usually retain their green color, a feature shared with *C. atropurpurea*. However, in *C. atropurpurea* the bract margin is distinctly recurved vs. not recurved and has 23–30 vs. 15–19 cross veinlets per 5 mm. All three species share the deciduous habit and presence of hairs on the upper surface of the leaf. Small individuals of *C. carolineae* might be mistaken for an especially large, robust individual of *C. micans*. However, *C. carolineae* is clearly distinguished from *C. micans* by the minutely pilose vs. glabrous adaxial leaf blade (excluding midrib), the glabrous vs. pilose and generally longer, > 40 cm vs. < 32 cm peduncle.

Etymology.—The specific epithet, *carolineae*, is in honor of Caroline Whitefoord (BM) in gratitude for her help at the BM herbarium during my visits over the past 40 years, her many valuable collections of Marantaceae for Flora Mesoamericana and moreover for showing me this important Honduran material.

ACKNOWLEDGMENTS

I am grateful to Caroline Whitefoord for making the recently collected Honduran specimens available for me to study at BM. I thank the curators of BM and MO for arranging the loan of this material to MO. The Missouri Botanical Garden provided support for my accommodations while working in the MO herbarium (organized, thanks to Olga Martha Montiel). The travel expenses for the trips to BM and MO were provided by Fred Ganders. Thanks to Roy Gereau (MO) for the Latin diagnosis, to Zoila Avila for digital photos of the isotype at HEH and to Cyril Nelson and George Pilz for their reviews and critical corrections. The holotype scan was provided by the Missouri Botanical Garden. I greatly appreciate the nomenclatural input of Kanchi Gandhi (GH).

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BOOK REVIEW

David W. Hall, William J. Weber, edited by Jason H. Byrd. 2011. **Wildflowers of Florida and the Southeast.** (ISBN: 978-0-615-39502-9, hbk.). D.W. Hall, Wildflower Book 8135 Meadowlark Court Melrose, FL 32666, U.S.A. (**Orders:** D.W. Hall, Wildflower Book 8135 Meadowlark Court Melrose, FL 32666; Amazon at http://www.amazon.com/Wildflowers-Florida-Southeast-David-Hall/dp/0615395023). $40 (plus s&h: $8 USPS Media Mail, $18.95 USPS Priority Mail), 819 pp.

Florida and the southeast U.S. possess a rich and abundant flora highlighted by their wildflowers. Florida ranks behind only Texas and California as the U.S. state with the most plant species. With this tome, the authors provide both amateur and professional botanists with an essential guide for identifying the local wildflowers of the region. The authors emphasize Florida, yet many of the featured plants occur through the Gulf and Eastern Coastal Plains, especially North Carolina and west into east Texas.

This book covers more than 750 species with descriptions and color photographs. The area of plant occurrence is listed along with habitat type, the frequency of occurrence, and flowering season for each species. Frequently, more than one common name is listed for each species; the first name listed being the one most commonly recognized. The treatment is organized by flower color and these colors were determined using the authors "best judgment." Some subjectivity was used in grouping the plants, for example purple is listed in the "blue" category and flowers that exhibit more than one color were grouped by the most common color for the species. In some cases, the authors have added photographic inserts displaying color variation. The flower color categories include red, pink, blue, orange, yellow, white, and green.

The book begins with a description of the treatment and an introduction to ecological communities that provides a brief description of each (coastal, salt flats, coastal scrub, etc) with select pictures. Within the treatment, the plant descriptions appear on one page, vis-à-vis the plant photos on the opposite page. The plant photos are of various sizes and some species have more than one photo. These photographs by William Weber are excellent quality and many point out key botanical characteristics useful for identification. The book closes with a glossary of botanical terms and an index of scientific and common names.

I recommend this book to those among us who are eager to learn these regional wildflowers. The breadth of the book makes it far more comprehensive than most wildflower guide books and that fact alone should see it widely utilized by botanists of the southeast. The high quality photographs and botanical and ecological information make this a valuable book for learning the wildflower flora of Florida and the southeast U.S.

—Kevin Janni, SWCA Environmental Consultants, Arlington, TX, kjanni@swca.com, and Research Associate, Botanical Research Institute of Texas, 1700 University Dr., Fort Worth, Texas 76107-3400, U.S.A

TWO NEW ENDEMIC SPECIES OF *CALATHEA* (MARANTACEAE) FROM PANAMA

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ABSTRACT

Calathea lanibracteata H. Kenn. and **Calathea confusa** H. Kenn., both endemic to Panama, are described as new. They share a similar habit, inflorescence and bract morphology with the closely related *C. allenii* Woodson as well as the absence of both secondary bracts and bracteoles. *Calathea lanibracteata* is distinguished from *C. allenii* and *C. confusa* by the narrowly ovate-elliptic vs. ovate leaf blade (leaf length to width ratio 5.42–7.17:1 vs. 1.57–2.83:1) and villous (hairs 3–4 mm) vs. glabrous or minutely tomentose petioles. *Calathea confusa* is most similar in appearance and most closely related to *C. allenii*. *Calathea confusa* differs by the more numerous minor veins between major lateral veins (7 vs. 1–3), greater distance between major veins ([6–]8–14 vs. 2.5–4.5 mm) and more widely spaced cross-veinlets (27 to 34 vs. 42 to 47 per 5 mm).

RESUMEN

Calathea lanibracteata H. Kenn. y **Calathea confusa** H. Kenn., ambas endémicas de Panamá, son descritas como nuevas. Con la estrechamente relacionada *C. allenii* Woodson comparten hábito similar, inflorescencias y morfología de las brácteas, así como la ausencia de brácteas secundarias y bractéolas. *Calathea lanibracteata* se distingue de *C. allenii* y *C. confusa* por sus hojas con la lámina foliar angostamente ovado-elíptica vs. ovada (la relación largo por ancho 5.42–7.17:1 vs. 1.57–2.83:1) y con el pecíolo villoso (pelos 3–4 mm) vs. glabro o diminutamente tomentoso. *Calathea confusa* es más parecida y estrechamente relacionada con *C. allenii*. *Calathea confusa* difiere de esta última por tener más venas menores entre las mayores laterales (7 vs. 1–3), mayor distancia entre venas mayores ([6–]8–14 vs. 2.5–4.5 mm) y venas teseladas más distanciadas (27 a 34 vs. 42 a 47 por 5 mm).

TAXONOMIC TREATMENT

Calathea lanibracteata H. Kenn., sp. nov. (**Fig. 1**). Type: PANAMÁ. Bocas del Toro: along old pipeline road from continental divide, forest, 900 m, 08°48'04"N, 82°15'04"W, 27 Dec 1986, *G. McPherson & J. Aranda 10170* (holotype: MO; isotype: PMA).

Haec species a *Calathea allenii* Woodson lamina foliari angustiore (7.4–10 vs. 12–18 cm lata) ambitu anguste ovato-elliptica vs. ovata (longitudinis cum latitudine ratione 5.42–7.17 vs. 1.57–2.83) apice acuminato-attenuata (vs. obtusa cum acumine) atque bracteis villosis (vs. glabris pilosisve) distinguitur.

Plants rhizomatous, caulescent, herbs, ca 1.5 m high; stem villous, hairs pale straw-colored, 2–3 mm. **Leaves** 3–4 (or more) basal with a single cauline leaf borne above an elongate stem internode, ca. 1.25 m; leaf sheath auriculate, reddish, villous, sheath of subtending leaf 11–12 cm, others at least 50 cm; petiole reddish (fide *Hammel et al. 14721*), villous, hairs 3–4 mm, 3.8–8.5 cm in subtending leaf, 32–44 cm in others; pulvinus elliptic in cross-section, tomentose adaxially, the rest glabrous but tomentose throughout just above junction to petiole, 3.9–4.5 cm; leaf blade stiff, chartaceous, narrowly ovate-elliptic, apex acuminate attenuate, base acute to 90°; 44–52 × 7.4–9.5 cm in subtending leaf, 55–71 × 8.5–10 cm in others, (length:width ratios 5.42–7.17:1) lateral veins 25 to 31 per 3 cm (measured at mid-point of each side of blade), cross-veinlets 36 to 40 per 5 mm, adaxial surface green, glabrous, midrib glabrous, abaxial surface light green, tomentose, hairs pale straw-colored, most dense along veins, more sparse on acumen, up to 0.5 mm, midrib tomentose along sides in basal ⅕, tomentose throughout apically. **Inflorescence** terminal, 1 per shoot, imbricate, fusiform, 8.3–14 × 3–3.7 cm; peduncle reddish, villous, 1.2–10.3 cm. **Bracts** 17–28, spirally arranged, central portion stiff, hardened, margins and apex soft herbaceous, elliptic, apical 7–10 mm of bract surface concave, forming a shallow channel centrally, apex truncate to rounded, apex slightly spreading, margin in apical half undulate, undulations ca. 8–10 per cm, 4.5–5.8 × (1.3–)1.8–3 cm, each bract subtending up to 3 or more flower pairs, abaxial surface of bracts reddish, villous throughout or with hairs sparser centrally and basally, adaxial surface villous at apical

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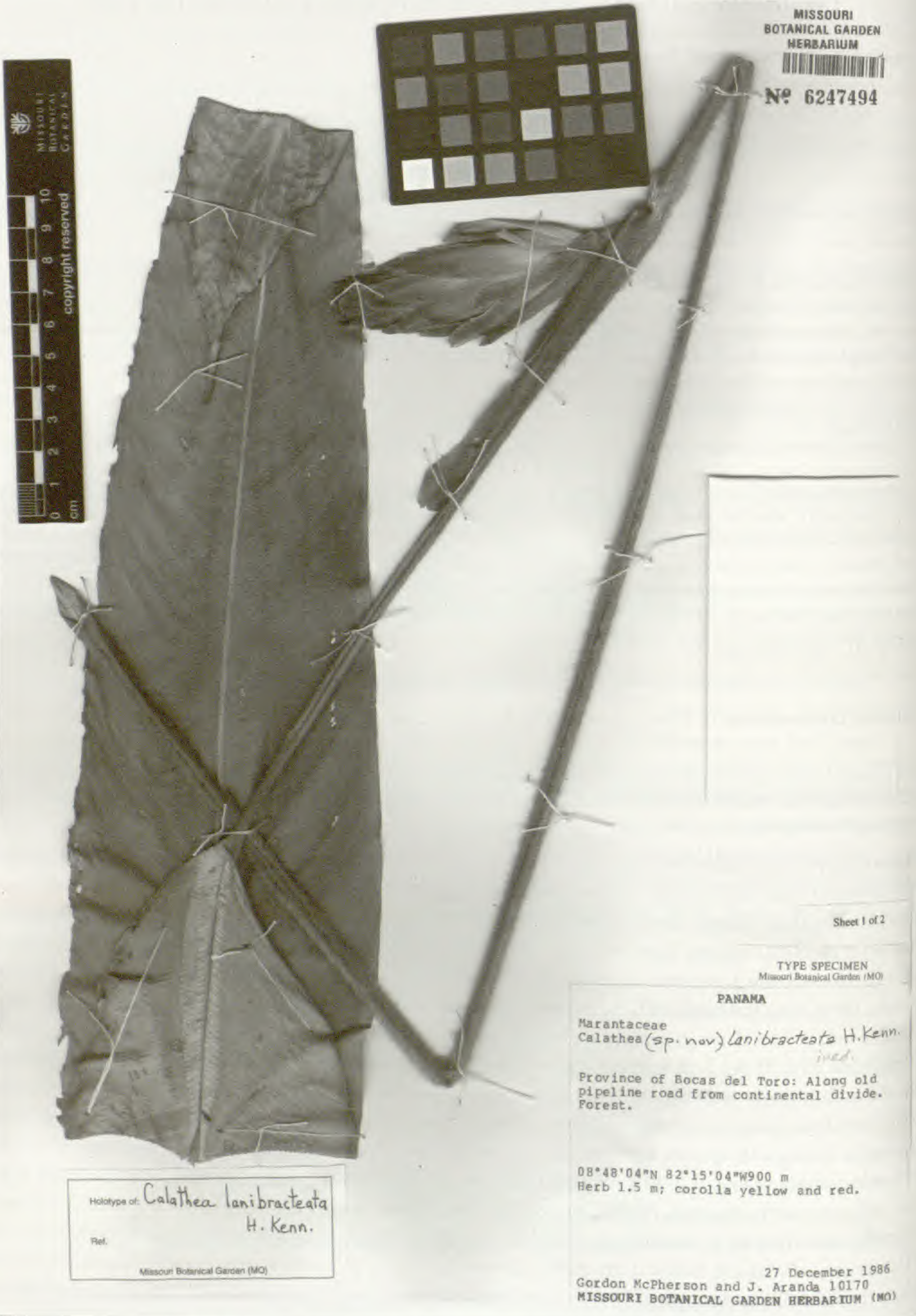
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TYPE SPECIMEN
Missouri Botanical Garden (MO)
PANAMA
Marantaceae
Calathea (sp. nov) lanibracteata H. Kenn.
ined.
Province of Bocas del Toro: Along old pipeline road from continental divide. Forest.
08°48'04"N 82°15'04"W900 m
Herb 1.5 m; corolla yellow and red.
27 December 1986
Gordon McPherson and J. Aranda 10170
MISSOURI BOTANICAL GARDEN HERBARIUM (MO)
Holotype of: Calathea lanibracteata H. Kenn.
Ref.
Missouri Botanical Garden (MO)

FIG. 1. *Calathea lanibracteata* H. Kenn. Holotype. Photo provided by Missouri Botanical Garden (*McPherson & Aranda 10170*, MO).

margin, subglabrous to glabrous in basal third; bicarinate prophyll membranaceous, ovate, apex acute, few sparse hairs to 1.5 mm on sides near junction with carina, the rest glabrous, 2–2.3 × ca. 1.1 cm, 0.5–0.8 cm wide, carina to carina; secondary bracts and bracteoles absent. **Flowers** open spontaneously, yellow throughout (*Hammel et al. 14721*) or yellow and red (*McPherson & Aranda 10170*). **Sepals** membranous, narrowly linear-elliptic, apex obtuse, margins inrolled appearing acute, glabrous, 18–20 × ca. 4 mm. **Corolla** tube with few sparse hairs 1.5 to 2 mm in apical half, less sparse toward lobes, 29–34 mm long; corolla lobes subequal, elliptic, obtuse, with scattered pilose hairs, hairs 0.1 to 0.25 mm, 16–18 × 4–5 mm. **Staminodes** 3; outer staminode obovate, emarginate, 10–12 × 9–10 mm; callose staminode totally callose, apex obtuse with minute acumen, ca. 15 mm; cucullate staminode ca. 6 mm; stamen with lateral petaloid appendage to 1 mm wide, extending to basal quarter of the anther; anther 3 mm; ovary sericeous apically, hairs straw-colored, 1.5–3 mm, glabrous basally. **Capsule** unknown.

Additional specimens examined: **PANAMÁ. Bocas del Toro:** Hill just S of Chiriquí Grande, at end of pipeline access road 2 mi N of 2nd large bridge N (10 mi) of continental divide, in forest along ridge, 350–500 m, 08°54'N, 82°10'W, 10 Mar 1986, *B. Hammel, G. McPherson & L. Sanders 14721* (MO).

Distribution and habitat.—*Calathea lanibracteata* is endemic to Panama, known only from two localities in Prov. Bocas del Toro, both from along the pipeline access road, from 350–900 m in wet or montane wet forest habitats.

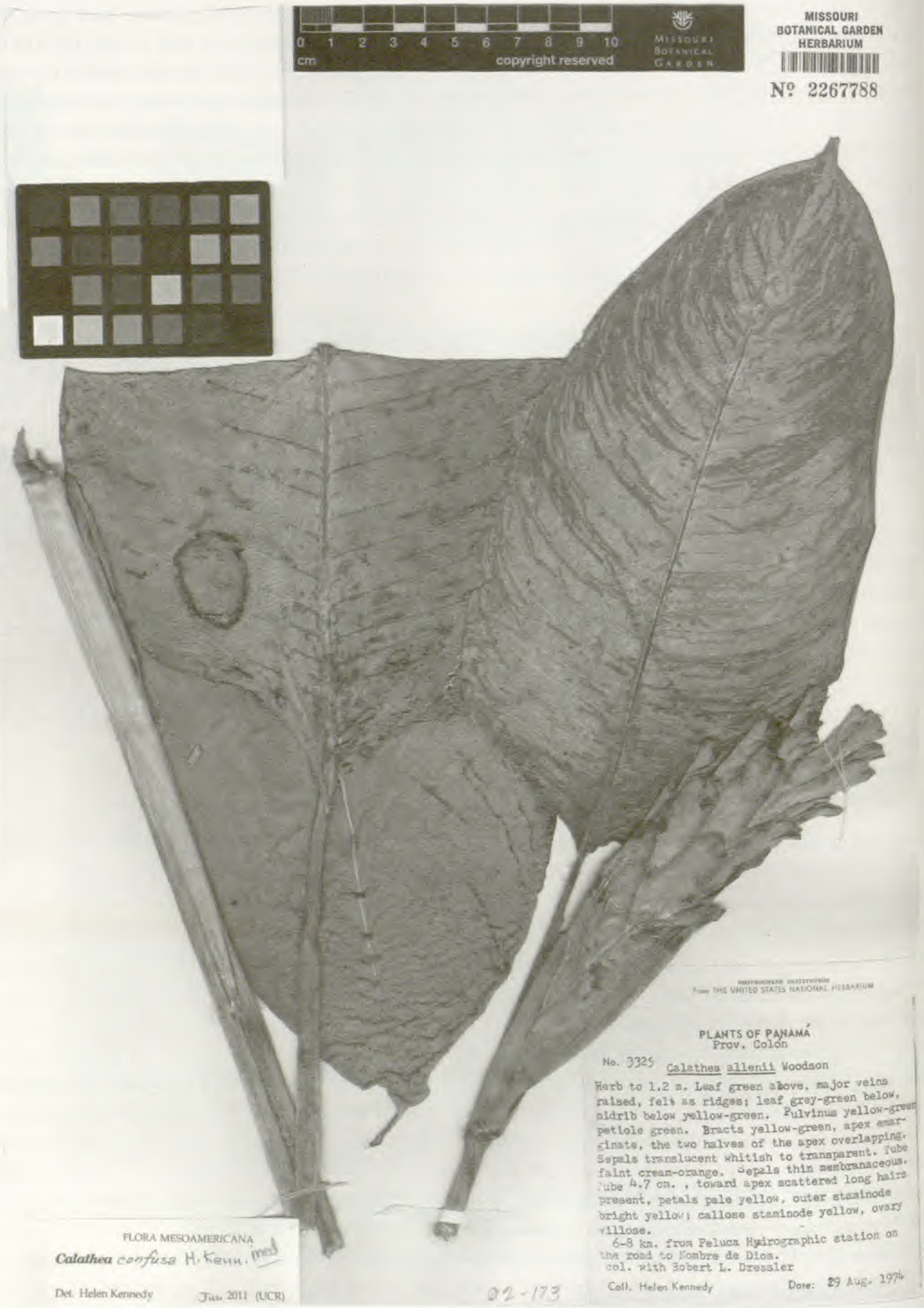
Discussion.—*Calathea lanibracteata* belongs to the informally treated "*Calathea lanicaulis* Group" as outlined in Flora of Ecuador (Kennedy 1988:47). These species are perennials characterized by their habit of several basal leaves with a single cauline leaf, subtending the inflorescence(-s) of spirally arranged bracts, borne above an elongate stem internode. *Calathea lanibracteata* is most closely related to *C. allenii* Woodson and *C. confusa*, sharing a similar habit, similar inflorescence and bract morphology, and the absence of both secondary bracts and bracteoles. *Calathea lanibracteata* differs from *C. allenii* and *C. confusa* by the narrowly ovate-elliptic vs. ovate leaf blade (leaf length to width ratio 5.42–7.17:1 vs. 1.57–2.83:1), narrower leaf blades (7.4–10 vs. 12–18 cm wide), apex acuminate attenuate vs. obtuse with acumen, base acute to 90° vs. obtuse, the villous (hairs 3–4 mm) rather than glabrous or minutely tomentose petioles, and the villous rather than glabrous to pilose bracts.

Etymology.—The specific epithet, *lanibracteata,* is in reference to the distinctly hairy bracts.

Calathea confusa H. Kenn., sp. nov. (**Fig. 2**). Type: PANAMÁ. Colón: 6–8 km from Peluca Hydro-graphic station on the road to Nombre de Dios, 29 Aug 1974, *H. Kennedy & R. L. Dressler 3325* (holotype: MO; isotypes: F, US).

Haec species a *Calathea allenii* Woodson venis minoribus numerosioribus (ca. 7 vs. 1 ad 3) inter venas laterales inter se distantioribus ([6–] 8–14 vs. 2.5–4.5 mm) atque venis tessellatis laxiorobis (27 ad 34 vs. 42 ad 47 per 5 mm) distinguitur.

Plants rhizomatous, caulescent herbs, 1–1.3 m. **Leaves** 3–5 basal with a single cauline leaf borne above an elongate stem internode, 30–55 cm; leaf sheath green, appressed tomentose at apex and along margin, the rest glabrous except very base sericeous, 8–15.5 cm in subtending leaf, 18–26 cm in basal leaves; petiole green, glabrous but occasionally minutely appressed tomentose, absent in subtending leaf, 16–41 cm in basal leaves; pulvinus yellow-green, sparsely tomentose adaxially with the rest glabrous to minutely tomentose throughout, 1.8–3 cm in subtending leaf, 3.3–4.7 in basal leaves; leaf blade coriaceous, major veins raised, felt as ridges, ovate, apex obtuse with acumen to slightly acuminate, acumen 1.5–3 cm, usually curved to the left, base obtuse, shortly attenuate, 22–32 × 12–16 cm in subtending leaf, 40–49 × 16–18 cm in basal leaves, (length:width ratios 1.57–2.83:1) lateral veins 20 to 27 (to 29) per 3 cm (measured at midpoint of each side of blade), (6–) 8–14 mm between major veins and commonly 7 minor veins between the major veins, cross-veinlets 27 to 34 per 5 mm, adaxial surface green, tomentose along major veins and throughout near right (inner coiled portion of blade) margin and acumen to nearly glabrous with sparse hairs along major veins only at base and on acumen, midrib tomentose to glabrous, abaxial surface grey-green, tomentose throughout to glabrous except sparsely tomentose near margin, midrib yellow-green, glabrous to densely tomentose, hairs 0.8–2 mm. **Inflorescence** terminal, 1 per shoot, imbricate, fusiform, 12–17.5 × 3.5–5.1 cm in flower, to 11 cm wide in fruit; peduncle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SMITHSONIAN INSTITUTION
From THE UNITED STATES NATIONAL HERBARIUM

PLANTS OF PANAMÁ
Prov. Colón

No. 3325 Calathea allenii Woodson

Herb to 1.2 m. Leaf green above, major veins raised, felt as ridges; leaf grey-green below, midrib below yellow-green. Pulvinus yellow-green petiole green. Bracts yellow-green, apex emarginate, the two halves of the apex overlapping. Sepals translucent whitish to transparent. Tube faint cream-orange. Sepals thin membranaceous. Tube 4.7 cm. , toward apex scattered long hairs present, petals pale yellow, outer staminode bright yellow; callose staminode yellow, ovary villose.

6-8 km. from Peluca Hydrographic station on the road to Nombre de Dios.
col. with Robert L. Dressler

Coll. Helen Kennedy Date: 29 Aug. 1974

FLORA MESOAMERICANA
Calathea confusa H. Kenn. med
Det. Helen Kennedy Jan 2011 (UCR)

FIG. 2. *Calathea confusa* H. Kenn. Holotype. Photo provided by Missouri Botanical Garden (*Kennedy & Dressler 3325*, MO).

green, 1–2.3 cm. **Bracts** 18–30, spirally arranged, central portion firm, margins and apex thinner, herbaceous, elliptic, apex emarginate, the two lobes of the apex overlapping, margin undulate apically, 6–8.5 × 2–3.4 cm, abaxial surface of bracts yellow-green, glabrous centrally, right margin appressed pilose, left margin only sparsely pilose, adaxial surface densely appressed pilose apically, just below the lobes, lobes sparsely pilose with shorter hairs apically; bicarinate prophyll membranaceous, ovate-triangular, apex acute, glabrous, 2.7–3.3 × 0.9–1.1 cm, ca. 0.5 cm wide, carina to carina; secondary bracts and bracteoles absent. **Flowers** open spontaneously; pedicel of flower pair sericeous, hairs 2 mm. **Sepals** membranous, narrowly elliptic to sublinear, apex acute, translucent whitish to transparent, glabrous, 30–36 × 3–4 mm. **Corolla** tube faint cream-orange, pilose, hairs to 1.5 mm, 38–40 mm; corolla lobes subequal, elliptic, acute to 90°, pale yellow, pilose, more densely so than on tube, 14–15 × 3–4 mm. **Staminodes** 3; outer staminode bright yellow, ca. 11 mm; callose staminode yellow, ca. 13 mm; cucullate staminode 8–9 mm; anther ca. 3 mm. Ovary villous, 4–4.5 × 1.5–2 mm. **Capsule** unknown; seed black, aril white (fide *Nee 7270*).

Additional specimens examined: **PANAMÁ. Colón:** Río Guanche, above the bridge on Portobelo Road, ca. 3–5 km above bridge, 50–200 m, 8 Jul 1976, *T. B. Croat 36967* (MO); Río Guanche, ca. 1.5 mi up-stream from the bridge, lowland wet forest, c. 10 m, 23 Aug 1972, *H. Kennedy 1495* (F); Teck Cominco Petaquilla mining concession, in plot C001, slope in forest, 87 m, 08°52'09"N, 80°42'48"W, 16 Sep 2007, *G. McPherson 19612* (MO); along Río Guanche, 6 km S of Portobelo, 2 km upstream from the bridge, dense growth of secondary tropical wet forest 5 m tall, 0–10 m, 6 Oct 1973, *M. Nee 7270* (MO). **San Blas:** El Llano-Cartí Road, 16.5 km from Panamerican Highway, border of Panama, montane forest along forest stream, medium light, 13 Apr 1977, *J.P. Folsom 2602* (MO). **Bocas del Toro:** Hill just S of Chiriquí Grande, at end of pipeline access road 2 mi N of 2nd large bridge N (10 mi) of continental divide, in forest along ridge and draws, 350–500 m, 08°54'N, 82°10'W, 10 Mar 1986, *B. Hammel et al. 14726* (MO).

Distribution and habitat.—Calathea confusa is endemic to Panama. It occurs along the Atlantic slope in Comarca San Blas (now Comarca Cuna Yala) west to Prov. Bocas del Toro from sea-level to near 500 m in moist to wet forest habitats. It is generally found in the shaded understory of the forest.

Discussion.—Calathea confusa also belongs to the informally treated "Calathea lanicaulis Group" as outlined in Flora of Ecuador (Kennedy 1988: 47). *Calathea confusa* is most closely related to *C. allenii* Woodson sharing a similar habit, inflorescence and bract morphology, and also the absence of the secondary bracts and bracteoles. These two sister species are so similar in general aspect, that *C. confusa* has been consistently mistaken for *C. allenii* by myself and others since the 1970's. When comparing a stack of *C. allenii* specimens with *C. lanibracteata* for differences, the difference of venation among the supposed *C. allenii* material became apparent. *Calathea confusa* differs from *C. allenii* in the more numerous minor veins between the major, raised, lateral veins (7 vs. 1 to 3), the greater distance between major veins ([6–] 8–14 vs. 2.5–4.5 mm) and the more widely spaced cross-veinlets (27 to 34 vs. 42 to 47 per 5 mm). The two tend to separate out ecologically as well. *Calathea confusa* occurs from sea-level to nearly 500 m in moist or wet forest habitats while *C. allenii* is found from 500–1000 (–1200) m in montane or cloud forest habitats.

Etymology.—The specific epithet, *confusa*, is in reference to its being confused with *C. allenii* and also the unusual (somewhat confusing) variability of leaf pubescence between populations.

ACKNOWLEDGMENTS

The Missouri Botanical Garden provided support for my accommodations while working in the MO herbarium (organized, thanks to Olga Martha Montiel). The travel expenses for the trip to MO were provided by Fred Ganders. I am very grateful to Gerrit and Jeany Davidse for their help in the MO herbarium, to Roy Gereau (MO) for the Latin diagnosis, Barry Hammel for the Spanish resumen and to Gordon McPherson for helpful suggestions, corrections, and his collections. The type scans were provided by the Missouri Botanical Garden.

REFERENCES

KENNEDY, H. 1988. *Calathea*. In: G. Harling and L. Andersson, eds. Flora of Ecuador 32:11–191. Berlings, Arlöv, Sweden. Pp. 14–126

BOOK REVIEW

Stewart McPherson and Donald Schnell. 2011. **Sarraceniaceae of North America.** (ISBN: 978-0-9558918-6-1, hbk.). Redfern Natural History Productions, 61 Lake Drive, Hamworthy, Poole, Dorset BH15 4LR, ENGLAND, UK. (**Orders:** inside UK 01202 686585, outside UK +44 1202 686585, www.redfernnaturalhistory.com, sales@redfernnaturalhistory.com). £34.99, 808 pp., 571 images.

This beautifully illustrated hefty tome (800 pages) is the second volume in the two-volume set of Sarraceniaceae. The authors chose to place *Sarraceniaceae of South America* as the first volume, because it describes *Helianthphora,* the largest genus of the family. It also includes introduction chapters. This one is the second volume of the two-volume set.) Each volume can stand independently but the authors heartily recommend using them together.

Obviously, when the reader—at first glance—leafs through this volume, he/she will be totally fascinated by the number of exquisite color photographs accompanying the described species—and recognize instantly that this volume is not only extremely heavy, it is too beautiful to risk taking into the field! Take your trusty (and presumably small) camera instead, keep careful notes and identifications, and compare and identify when you're comfortably back at home or office!

The authors not only describe the plants, they carefully observed and recorded data re: identification of location, nature of climate, and when possible, how the plants grow, react to natural conditions, and—especially—the relationships between plants and insects and/or small rodents.

According to the carefully observed and recorded data of the authors, some 730 species representing 17 genera included carnivorous species—two identified as "snap drops" and seven as "pitcher plants."

This is an extremely well done and very valuable contribution. The authors and artists have obviously dedicated themselves to intensive research. They have also included maps, indicating specific areas where various species grow; they have identified historical backgrounds for many of the species; and they have included helpful current information about Societies, Recommended Suppliers, various specialty places, e.g., Hampshire Carnivorous Plants; New Taxa, and a Glossary.

—Helen Jeude, Volunteer,
Botanical Research Institute of Texas, 1700 University Dr., Fort Worth, Texas 76107-3400, U.S.A

BOOK NOTICES/REVIEW FORTHCOMING

Stewart McPherson, Andreas Wistuba, Andreas Fleischmann, and Joachim Nerz. 2011. **Sarraceniaceae of South America.** (ISBN: 978-0-9558918-7-8, hbk.). Redfern Natural History Productions, 61 Lake Drive, Hamworthy, Poole, Dorset BH15 4LR, ENGLAND, UK. (**Orders:** inside UK 01202 686585, outside UK +44 1202 686585, www.redfernnaturalhistory.com, sales@redfernnaturalhistory.com). $58.00, 562 pp., 488 images.

An elegant and beautiful volume! Hiding in the appendix are four newly described species and one new combination, each with a beautifully executed line drawing: *Heliamphora arenicola* sp. nov., *Heliamphora ceracea* sp. nov., *Heliamphora collina* sp. nov., *Heliamphora parva* comb. et stat. nov., *Heliamphora purpurascens* sp. nov.

Christian Ziegler. Introduction by Michael pollan. 2011. **Deceptive Beauties: The World of Wild Orchids.** (ISBN: 978-0-226-98297-7, hbk.). The University of Chicago Press, Chicago, Illinois 60637, U.S.A. (**Orders:** www.press.uchicago.edu). $45, 183 pp., color photos throughout, 9.75" × 9.75".

Deceivingly beautiful!

PARADRYMONIA APICAUDATA (GESNERIACEAE), A NEW SPECIES FROM WESTERN COLOMBIA

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ABSTRACT

A new species is described and illustrated from the Pacific slope of the Cordillera Occidental in the western Andes of Colombia. **Paradrymonia apicaudata** (Gesneriaceae: Episcieae) is distinguished from other species in the genus by the combination of spathulate leaf blades with a caudate apex, linear calyx lobes, and salverform white corollas.

RESUMEN

Se describe y se ilustra una nueva especie, **Paradrymonia apicaudata** (Gesneriaceae: Episcieae), de la vertiente del pacífico de la Cordillera Occidental en los Andes de Colombia. La nueva especie se distingue de otras especies del género por sus láminas espatuladas con ápice caudado, por sus flores blancas hipocrateriformes y por sus lóbulos del cáliz lineares.

KEY WORDS: Colombia, Gesneriaceae, *Paradrymonia*, Taxonomy

INTRODUCTION

The plant family Gesneriaceae is mostly tropical or subtropical with over 3500 species distributed in 150–160 genera (Weber 2004; Weber & Skog 2007). The family is divided into four subfamilies with the subfamily Gesnerioideae found almost exclusively in the Neotropics (Burtt & Wiehler 1995; Smith & Carrol 1997). Although different tribal arrangements are recognized in the literature based on morphological data (e.g., Hanstein 1854; Fritsch 1893–1894; Wiehler 1983), more recent studies based on molecular evidence divide the subfamily Gesnerioideae into eight tribes (Weber 2004; Skog & Boggan 2007; Weber & Skog 2007). Of the eight tribes, Episcieae is the largest and most diverse with 22 genera and an estimated 784 species (Clark et al. 2006; Clark 2009).

Paradrymonia Hanst. with 38 currently recognized species is the fourth largest genus in tribe Episcieae after *Columnea* L. (200+ spp.), *Drymonia* Mart. (100+ spp.) and *Nautilocalyx* Linden ex Hanst. (ca. 60 spp.) (Clark 2009). The genus occurs throughout the Neotropics except southeast Brazil and the Caribbean, with centers of diversity in Colombia and Ecuador. Ongoing phylogenetic studies support that traditionally recognized *Paradrymonia*, *Nautilocalyx*, and *Chrysothemis* are not monophyletic. The new species described here shares the following morphological features with currently recognized members of an informal clade comprised of *Paradrymonia*: facultative epiphytic herbs; leaves clustered in a basal rosette; petioles U-shaped in cross section; corollas trumpet-shaped to salverform; anther dehiscence longitudinal; leaf pairs anisophyllous; and fruits a semi-fleshy bivalved dehiscent capsule. An ongoing taxonomic revision by the first author on *Paradrymonia* has revealed a new species endemic to Colombia that is described here.

J. Bot. Res. Inst. Texas 6(1): 65 – 69. 2012

Paradrymonia apicaudata M.M. Mora & J.L. Clark, sp. nov. (**Fig. 1**). Type: COLOMBIA. Valle: from Campoalegre into area controlled by Corporación Valle del Cauca, trail uphill behind last camp (El Chanco), 04°00'N 076°40'W, 400–610 m, 17 Feb 1989, *J.F. Smith, R. Bernal, X., Londoño and W. Devia 1357* (holotype: SEL; isotypes: F, MO, US, WIS).

Differs from other congeners by the combination of the following characters: epiphytic herbaceous habit; anisophyllous leaves; blades spathulate with decurrent base and caudate apex, sericeous surface, and denticulate margins; linear calyx lobes; and white salverform corollas.

Facultative epiphyte. Stems subwoody, subquadrate, elongate and creeping with erect shoots, internodes 3–6 cm long near base, becoming apically clustered, rhytidome glossy and tan, adventitious roots present. Leaves opposite, unequal in a pair, the larger leaf with petioles 1–2(–4) cm long, cross section U-shaped, wine-red, densely sericeous; the blade 8.5–24 × 3.5–6.5 cm wide, spathulate to oblanceolate with denticulate margins, base decurrent on petiole, apex abruptly acuminate to caudate, dark green above, light green below, sometimes tinged with purple, matte (non-glossy), sericeous on both surfaces, young leaves densely sericeous; the lateral pairs of veins 10–14(–16), departing the midrib at 40–50° angle. The smaller leaf strongly reduced, to 2 cm long, linear-lanceolate with denticulate margins. Inflorescence a reduced pair-flowered cyme, of 1–2 flowers in axillary clusters, the prophylls linear-lanceolate, denticulate, less than 2 cm long, reddish, sericeous; the pedicels 0.8–1.5 cm long, rose-colored, sericeous. Calyx lobes subequal 15–30 × 1–2 mm, linear, sericeous, pale green to yellowish green, with one or two subovoid teeth on the margin, the teeth sometimes in pairs. Corolla oblique relative to the calyx, ca. 3.5 cm long, salverform with a flattened limb and spreading lobes, spurred at base, pilose, proximal half a narrow tube, white, distal half gradually expanding with yellowish hues inside the tube, pilose outside, with short glandular hairs inside, the lobes 5, subequal, 0.5–0.6 cm, slightly broader than long. Androecium with 4 stamens, included, didynamous, 1.8–2.3 cm long, the filaments adnate for up to 3 mm from the base of the corolla tube, white, glabrous, each anther apically coherent in a pair, each thecae ca. 1 mm long, the thecae dehiscent by longitudinal slits. Gynoecium with the ovary ovoid, 7 mm long, densely sericeous, style up to 2.5 cm long, densely glandular-pilose, stigma capitate, nectary a bilobed dorsal gland, ca. 2 mm long, entire, glabrous. Fruit a bivalved semi-fleshy (not succulent) capsule, green, and sericeous. Seeds oblong-ovoid, tapered at both ends but more acutely at one end, 1.2–1.4 × 0.3–0.4 mm, light reddish brown marked with vertical striae.

Distribution and habitat.—*Paradrymonia apicaudata* is endemic to Colombia and is known from the western foothills of the Cordillera Occidental in the departments of Chocó and Valle. Its habitat ranges from Tropical wet forest (Twf) to Tropical rain forest (Trf) to Premontane (P) life zones (Holdridge et al. 1971). Collections range from sea level to 700 m in primary forest, fragmented tracts of primary forest with few large trees and many epiphytes, or growing on steep rocky roadside embankments.

Phenology.—*Paradrymonia apicaudata* has been collected in flower in October to May and in fruit in February to May.

Paradrymonia apicaudata is distinguished from other species in the genus by the combination of sericeous pubescence on the leaf blades, pedicels, and calyces; spathulate leaf blades with conspicuous caudate apices and denticulate margins; linear calyx lobes with subovoid teeth; and white salverform corollas. *Paradrymonia apicaudata* is similar to *P. ulei*, an endemic species from the northeastern Andes of *Peru*. Both species have salverform corollas with sericeous pedicels and calyces. However, *Paradrymonia apicaudata* differs from *P. ulei* by the presence of white corollas (vs. red-orange), linear calyces (vs. lanceolate) and conspicuously caudate leaf apices (vs. acuminate).

Etymology.—The specific epithet, apicaudata, is in reference to the apical portion of the leaf blade. The leaf apex is elongate and "tail-like" as in the order of Amphibians, Caudata (salamanders and newts), which is defined by the presence of tails as adults.

Conservation and IUCN Red List category.—Most of the specimens of *Paradrymonia apicaudata* are from the Bajo Calima region in the Department of Valle on the Pacific coast of Colombia near Buenaventura. From the 1950s until 1995, the Bajo Calima site was a timber concession to Cartón de Colombia. The site was logged on a 30-year rotational basis and during the late 1980s and 1990s the same timber company encouraged the

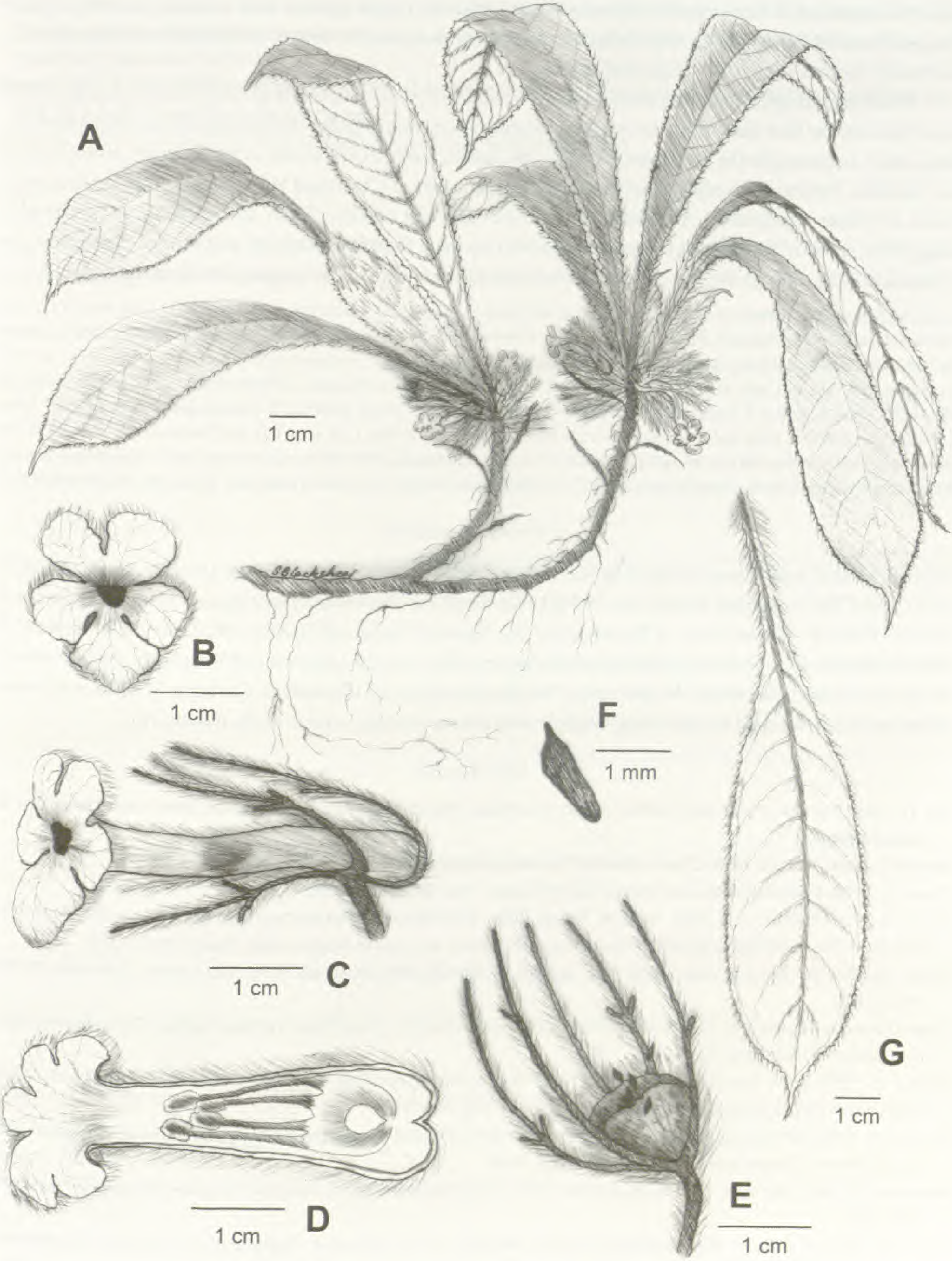

Fig. 1. Illustration of *Paradrymonia apicaudata*. **A.** Apical rosette habit. **B.** Front view of corolla. **C.** Lateral view of flower. **D.** Corolla open to show position of androecium. **E.** Persistent calyx and bivalved capsule with seeds. **F.** Seed. **G.** Leaf blade showing caudate apex. (A from E.P. *Killip & H. Garcia 33424* (US); B, C & D from *M. Monsalve 819* (MO); E from *A. Juncosa 1551* (MO); and F from the holotype, *J.F. Smith et al. 1317* (WIS)).

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Conservation and IUCN Red List category.—Most of the specimens of *Paradrymonia apicaudata* are from the Bajo Calima region in the Department of Valle on the Pacific coast of Colombia near Buenaventura. From the 1950s until 1995, the Bajo Calima site was a timber concession to Cartón de Colombia. The site was logged on a 30-year rotational basis and during the late 1980s and 1990s the same timber company encouraged the

WEBER, A. 2004. Gesneriaceae. In: K. Kubitzki and J.W. Kadereit, eds. The families and genera of vascular plants. Vol. 7. Flowering plants, dicotyledons: Lamiales (except Acanthaceae including Avicenniaceae). Springer-Verlag, Berlin and Heidelberg, Germany. Pp.63–158.

WEBER, A. AND L.E. SKOG. 2007 (onward): The genera of Gesneriaceae. Basic information with illustration of selected species. Ed. 2. http://www.genera-gesneriaceae.at.

WIEHLER, H. 1983. A synopsis of the neotropical Gesneriaceae. Selbyana 6:1–219.

BOOK REVIEW

Bernardo Gut. 2008. **Trees in Patagonia.** (ISBN: 978-3-7643-8837-9, hbk.). Birkhauser Verlag AG, P.O. Box 133, CH-4010 Basel, SWITZERLAND. (**Orders:** www.springer.com). $89.95, 283 pp., 760 illustrations, 600 color photos, 9" × 12.25".

When I first started to examine this book I thought that I was going to be looking at something for the Patagonian area that would be comparable to those written by Texas authors Neil Sperry, Howard Garrett, or Sally Wasowski. Rather it is something between the works by those authors and is intended for use as a field guide.

From the back cover: "This book is a guide to the native trees and approximately 95% of the introduced arboreal species of Argentine and Chilean Patagonia. Introductory chapters convey an overview on what is termed 'Patagonia', as well as on the geology, climate, soils, and vegetation of Southern South America. Keys based on vegetative characters and richly illustrated descriptions of more than 170 species form the core of the manual. These chapters are followed by concise entries on afforestations, urban trees, and plantations of fruit trees in climatic enclaves. Renowned experts describe the most important National Parks of both Argentine and Chilean Patagonia. The last chapter is devoted to Carl Skottsberg and his remarkable expedition through Patagonia a hundred years ago."

Following the chapter on Skottsberg are a number of appendices including a glossary, abbreviations, an extensive bibliography, and the English, Spanish, and scientific plant names.

Each species is provided with a botanical description, followed by some or all of the following: status and distribution, hardiness, uses, habitat, elevation, and remark(s). Each is illustrated by color photographs or drawings, sometimes of the tree, its flowers, fruits or leaves.

This was intended to be a 'field guide' but its size weighs against that usage. It is an excellent resource and contains a considerable amount of useful secondary information such as a good botanical key and descriptions of the National Parks, fruit trees in cultivation, and trees in urban landscapes.

This book is recommended for purchase by major academic libraries with a botanical or horticultural interest and researchers with an interest in the region. It will be useful to those who are attempting to establish or to maintain a landscape or garden which includes trees.

—Gary L. Jennings, Librarian,
Botanical Research Institute of Texas, 1700 University Drive, Fort Worth, Texas 76107-3400, U.S.A.

BOOKS RECEIVED/REVIEWS FORTHCOMING

William A. Weber and Ronald C. Wittmann. 2012. **Colorado Flora: Western Slope. A Field Guide to the Vascular Plants, Fourth Edition.** (ISBN: 978-1-60732-142-2, pbk.). University Press of Colorado, 5589 Arapahoe Ave., Suite 206C, Boulder, CO 80303, U.S.A. (**Orders:** http://www.upcolorado.com/content/_welcome, 800-627-7377). $27.95, 608 pp., 108 line drawings, 1 map, 4 tables. 5.5" × 8.5".

William A. Weber and Ronald C. Wittmann. 2012. **Colorado Flora: Eastern Slope. A Field Guide to the Vascular Plants, Fourth Edition.** (ISBN: 978-1-60732-140-8, pbk.). University Press of Colorado, 5589 Arapahoe Ave., Suite 206C, Boulder, CO 80303, U.S.A. (**Orders:** http://www.upcolorado.com/content/_welcome, 800-627-7377). $27.95, 608 pp., 104 line drawings, 1 map, 4 tables. 5.5" × 8.5".

Elray Nixon, Illustrated by Bruce Lyndon Cunningham. 2012. **Trees, Shrubs, and Woody Vines of East Texas, Third Edition.** (ISBN: 978-0-934115-10-0, pbk.). Bruce Lyndon Cunningham. (Orders: brucelc@suddenlink.net or call 936.569.6965). $59.95, 256 pp., 345+ b/w illustrations, 8" × 10".

J. Bot. Res. Inst. Texas 6(1): 70. 2012

DRYMONIA ATROPURPUREA (GESNERIACEAE), A NEW SPECIES FROM NORTHWESTERN SOUTH AMERICA

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ABSTRACT

Recent expeditions to the western Andean slopes of Colombia and Ecuador and preliminary work on a revision of *Drymonia* (Gesneriaceae) have resulted in the discovery of a new species. The new species, **Drymonia atropurpurea** Clavijo & J.L. Clark, is distinguished from other congeners by large (up to 46 cm long) elliptic to oblong leaves, dark purple bullate calyces, and angulate (bent) corolla tubes.

RESUMEN

Expediciones recientes a la vertiente occidental de los Andes colombianos y ecuatorianos, y el trabajo preliminar de revisión del género *Drymonia* (Gesneriaceae) han permitido descubrir una nueva especie: **Drymonia atropurpurea** Clavijo & J.L. Clark, que se distingue de otras especies del género por sus hojas grandes (hasta 46 cm de largo), de elípticas a oblongas; por el cáliz púrpura oscuro y bullado, y por el tubo de la corola angulado (geniculado).

KEY WORDS: Gesneriaceae, *Drymonia*, taxonomy, Ecuador, Colombia

INTRODUCTION

The flowering plant family Gesneriaceae is a member of the order Lamiales (APG III 2009) and is primarily pantropical with extensions into the subtropics and temperate regions (Weber 2004; Skog & Boggan 2006). The family contains ca. 150 genera and ca. 3500 species and is classified into four major groups (Weber 2004). In the Neotropics the highest concentration of species diversity for the family is found in Colombia with 32 genera and more than 400 species (Kvist et al. 1998), followed by Ecuador with 29 genera and 240 species (Skog & Kvist 1997), Brazil with 28 genera and 207 species (Forzza et al. 2010), and Peru with 28 genera and 150 species (Kvist et al. 2005).

Drymonia, with 74 species, is the third largest genus of Gesneriaceae in the Neotropics, after *Columnea* (272 species) and *Besleria* (200 species) (Weber 2004). It ranges from Mexico to Bolivia, including Brazil, French Guiana, and the Caribbean. The highest species richness is found in Colombia with 31 species (Clavijo & Clark 2008) and Ecuador with 30 species (Clark et al. 2006). *Drymonia* is a genus of terrestrial subshrubs, vines or herbaceous epiphytes with campanulate, tubular or hypocyrotid flowers. *Drymonia* is especially diverse in the tropical wet forests along the western Andean slopes of southern Colombia and northern Ecuador where there are over 35 species.

Drymonia has a wide range of morphological variation as a result of different pollinators and dispersal mechanisms (Roalson et al. 2005; Clark et al. 2006). The morphological variation has made *Drymonia* a difficult genus to circumscribe. Ongoing studies on pollination biology have facilitated a better understanding of the morphological variation that pertains to pouched flowers (bird pollinated) and campanulate flowers (euglossine bee pollinated).

TAXONOMIC TREATMENT

Drymonia atropurpurea Clavijo & J.L. Clark, sp. nov. (**Fig. 1**). TYPE: ECUADOR. ESMERALDAS: Parroquia: Alto Tambo, remnant patch of primary forest on north side of road between Durango and Alto Tambo on Hwy San Lorenzo–Ibarra, 0°57'59" N, 78°33'39" W, 695 m, 29 May 2008 (fl, fr), *J.L. Clark 10443* (HOLOTYPE: US; ISOTYPES: BRIT, K, MO, NY, QCNE, UNA).

Differs from other congeners by the subshrub habit, relatively large leaves to 46 cm long, dark purple inflorescence bracts, bullate purple dark calyx, and angulate corolla tube.

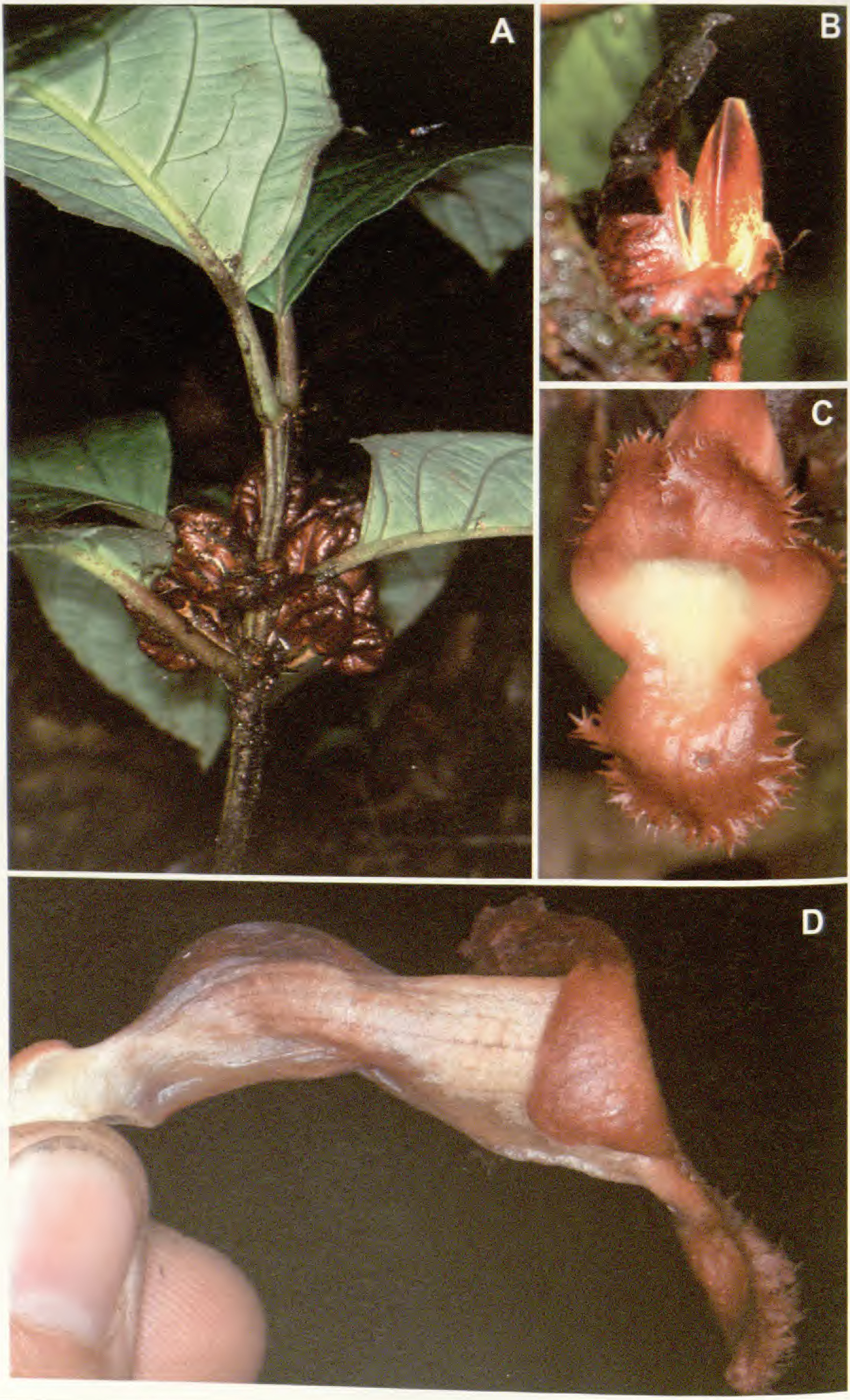

Fig. 1. *Drymonia atropurpurea*. **A.** Habit showing elongate unbranched stem. **B.** Immature fleshy bivalved capsule. **C.** Face view of corolla. **D.** Lateral view of corolla showing angulation. (Photos A, C and D by J.L. Clark & B by L. Clavijo; A. *J.L. Clark 7143*; B. *L. Clavijo 1689*; C & D. *J.L. Clark 10443*).

Terrestrial subshrub, 1–1.5 m tall. **Stem** erect, unbranched, quadrangular in cross–section, shallowly sulcate, subwoody, green with red spots, glabrate basally, strigose apically, trichomes ca. 1 mm long, unbranched, yellow when dry; internodes (2.4–)5–15 cm long. **Leaves** opposite, decussate, equal in a pair; petioles 2.8–5.2 cm long, terete, green with red spotting, base swollen with several pinkish gland–like enations, glabrate to strigillose, strigose in the immature leaves, trichomes less than 1 mm long, yellow when dry; blade elliptic to oblong, 20–46 cm long, 6.3–21 cm wide, coriaceous, upper and lower surface green, sometimes lower surface green suffused with light red, apex acuminate, base cuneate or sometimes slightly oblique, margin serrulate, becoming revolute when dry, upper surface glabrous, lower surface glabrate; 6–8 lateral pairs of veins, venation raised below, green when live, red–brown when dry, main vein strigose, secondary veins strigillose, higher order venation only evident abaxially, green when live, red–brown when dry. **Inflorescence** a reduced pair–flowered cyme, 1 inflorescence per axil with 2–6 flowers; peduncle reduced to less than 1 mm long; inflorescence bracts ca. 23 mm long, ca. 12 mm wide, dark purple, strigillose, elliptic, apex acute, margin entire; floral bract one, 10–23 mm long, 1–8 mm wide, dark purple, linear to spatulate, base decurrent, apex rounded, margin entire, strigose to strigillose towards the apex; pedicel 16–32 mm long, red–orange, strigillose to strigose, glands scattered along the pedicel. **Calyx** dark purple, coriaceous, bullate, persistent in fruit, apex rounded, margin entire, base truncate to cordate, glabrate to strigose at the base, venation evident, the main vein strongly raised abaxially, strigose; calyx lobes 5, 4 nearly equal, 5th lobe (dorsal) slightly smaller, lobes fused at the base for 2–4 mm, ventral lobes 18–25 mm long, 14–21 mm wide, rotund, margin occasionally involute, lateral lobes 19–28 mm long, 13–17 mm wide, ovate, margin involute apically, dorsal lobe 14–19 mm long, 8–13 mm wide, ovate. **Corolla** zygomorphic, funnelform; corolla tube strongly angulate (bent) at the base, posture perpendicular relative to the calyx, ca. 29 mm long, outer surface beige ventrally with some darker longitudinal lines, red–brown dorsally, glabrous; corolla base ca. 7 mm wide, spur ca. 11 mm long, ca. 8 mm wide, white; throat ca. 14 mm wide, light yellow, glandular trichomes on the inner surface; corolla lobes 5, subequal, red–brown, apex obtuse, margin fimbriate, glabrous, ventral lobe longer than the other four lobes, spreading, ca. 13 mm long, ca. 15 mm wide, orbicular, upper lobes reflexed, 6 mm long, 6–7 mm wide, orbicular, lateral lobes reflexed, 9–10 mm long, 8–9 mm wide, rotund. **Androecium** of 4 stamens, didynamous, 24–28 mm long, adnate to the corolla tube for 9–10 mm, glabrous, staminode absent; anthers oblong, dehiscence by basal pores that develop into longitudinal slits, 6–7 mm long, 1.5–2 mm wide. **Gynoecium** with a single dorsal nectary gland, ovate, emarginate, 2.0–2.6 mm long; ovary superior, ca. 6 mm long, ca. 4 mm wide, glabrous, oblong, laterally compressed; style ca. 13 mm long, strigillose; stigma stomatomorphic, ca. 3 mm diameter. **Fruit** a bivalved laterally compressed fleshy capsule, ca. 18 mm long, ca. 14 mm wide, rounded, externally red–brown with yellow patches towards the apex and the base, glabrous; seeds numerous, immersed in a mass of fleshy funicular tissue, 0.4–0.6 mm long, 0.2–0.3 mm wide, brown when dry, rhombic, covered by a transparent aril.

Distribution and habitat.—Drymonia atropurpurea is known from wet forests on the western slopes of the Andes in northern Ecuador and southern Colombia, between 350 and 1400 meters. In Colombia it has been found in the understory of protected cloud forests that are part of the Río Ñambí Natural Reserve in the Department of Nariño above 1000 meters. In northern Ecuador *D. atropurpurea* has been collected in remnant patches of wet forest between 350 and 695 meters in the Esmeraldas Province along the San Lorenzo–Ibarra highway.

Drymonia atropurpurea is distinguished from other congeners by the subshrub habit; large elliptic to oblong leaves to 46 cm long; dark purple bracts (inflorescence and floral) and calyces (Fig. 1A); bullate calyx lobes; corolla tube strongly angulate (bent) at the base (Fig. 1D); corolla posture perpendicular relative to the calyx; and dark reddish–brown corolla lobes. *Drymonia atropurpurea* is similar to *Drymonia turrialvae* because of their large leaves, relatively large funnelform corollas, and similar inflorescence. The two species are differentiated by the subshrub habit in *D. atropurpurea* in contrast to the herbaceous habit in *D. turrialvae*; the non–bullate leaves with the abaxial surface green in *D. atropurpurea* in contrast to the bullate leaves with the abaxial surface wine-red in *D. turrialvae*; and a laterally compressed fleshy capsule in *D. atropurpurea* (Fig. 1B) in contrast to a globose indehiscent berry in *D. turrialvae*.

Etymology.—The specific epithet is Latin for dark purple: *atro* (=black), *purpurea* (=purple), in reference to the dark purple color of the bracts and calyx.

Conservation and IUCN Red List category.—*Drymonia atropurpurea* is known from recently documented populations in Ecuador and Colombia. The population in Colombia is from the well-established protected area, Río Ñambí Natural Reserve (Nariño). The population from Ecuador is from an area that is almost completely deforested along the San Lorenzo–Ibarra highway. According to the IUCN Red List criteria for estimated range, area of occupancy and population size (IUCN 2001), and considering the uncertain future of habitat conservation in Ecuador, *Drymonia atropurpurea* should be listed in the category NT (Nearly Threatened).

Paratypes. **COLOMBIA. Nariño:** Municipio Barbacoas, Corregimiento Altaquer, vereda El Barro. Reserva Natural Río Ñambí, Sendero hacia el río Ñambí. 1180–1400 m, 26 Jul 2011 (fr), *L. Clavijo, M. Flores & A. Vásquez 1689* (COL, PSO). **ECUADOR. Esmeraldas:** Parroquia San Lorenzo, Cantón Alto Tambo, Border region of Awá Indigenous Territory, entrance to the Río Bogotá community (future biological research station), near Quebrada Pambilar, 350–600 m, 0°58'57" N, 78°35'50" W, 12 Feb 2003 (fl, fr), *J.L. Clark 7145* (QCNE, SEL, UNA, US).

ACKNOWLEDGMENTS

Support for this study was provided by the National Science Foundation (DEB–0841958 & DEB–0949169 to JLC) and the Nellie Sleeth Scholarship from The Gesneriad Society, Inc. (to LC). We thank Alain Chautems, Christian Feuillet, Alejandro Zuluaga and Steve Ginzbarg for providing helpful reviews; the Herbario Nacional Colombiano (COL) for access to their collections; and the Fundación Ecológica los Colibríes de Altaquer (FELCA), especially Alex Vásquez and Mauricio Flores, for logistical support for the 2011 expedition to the Río Ñambí Natural Reserve in Nariño (Colombia).

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A TAXONOMIC STUDY OF THE GALÁPAGOS ENDEMIC *VARRONIA* (CORDIACEAE) SPECIES WITH NOMENCLATURAL NOTES

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ABSTRACT

This study revises the taxonomy of *Varronia* P. Br. (Cordiaceae) species endemic to the Galapagos Islands and presents a key that can more reliably distinguish the species using vegetative characters alone. We conclude that there are four endemic species of Galápagos *Varronia* distributed across ten islands: *V. canescens* Andersson (syn = *V. anderssonii*, nom. illeg.), *V. leucophlyctis* (Hook. f.) Andersson, *V. scouleri* (Hook. f.) Andersson, and *V. revoluta* (Hook. f.) Andersson. Although most species share island distributions, species are not found in close proximity together and no obviously intermediate or putatively hybrid individuals were observed. The endemic species appear to be distylous, and preliminary data suggest these species may be obligate outcrossers. The findings of our study will assist efforts by park managers and other researchers to determine the conservation status of each species and to develop appropriate conservation measures in line with the life-history of the species.

RESUMEN

El propósito de este estudio fue revisar la taxonomía de las especies endémicas de *Varronia* P. Br. (Cordiaceae), de las Islas Galápagos y hacer una clave taxonómica que pueda distinguir con mayor fiabilidad las especies usando solo caracteres vegetativos. Llegamos a la conclusión que hay cuatro especies endémicas de *Varronia* en Galápagos, distribuidas en diez islas: *V. canescens* Andersson (syn = *V. anderssonii*, nom. illeg.), *V. leucophlyctis* (Hook. f.) Andersson, *V. scouleri* (Hook. f.) Andersson, y *V. revoluta* (Hook. f.). Aunque la mayoría de especies comparten su distribución en las islas, las especies no se encuentran muy cerca entre sí y obviamente no fueron observados individuos intermedios o supuestamente híbridos. Las especies endémicas parecen ser de doble estilo[1] distilas, y los datos preliminares indican que estas especies pueden ser alógamas obligadas. Los hallazgos de nuestros estudios ayudarán a los encargados de gestionar el Parque Nacional y a otros investigadores para determinar el estatus de conservación de cada especie y desarrollar medidas adecuadas de conservación de acuerdo con la historia vital de las especies.

INTRODUCTION

Background

Within the past several decades, the Galápagos Islands have become increasingly exposed to threats from invasive species and rapidly expanding human populations (Atkinson et al. 2010; Tapia et al. 2010). Invasive nonnative species pose the greatest threat to the native and endemic species on the Islands (Trueman et al. 2010), and the Galápagos are particularly vulnerable to invasion by alien species (Denslow et al. 2009; Reaser et al. 2007). Accurate identification and documentation of the flora of the Galápagos is essential for conservation efforts, particularly for those species that suffer from taxonomic uncertainty. The purpose of this study was to review and update the characterization of the endemic species of genus *Varronia* and to create a more complete identification key for them based on foliar morphology. Scientists have been unable to accurately evaluate these species for conservation status because morphological distinctions between species do not hold up in practice. This uncertainty may have discouraged research on these species of *Varronia*.

Site Description

The Galápagos archipelago is composed of volcanic islands located in the Pacific Ocean with a total land area of 7880 km^2 within a geographical area of 45,000 km^2 (Neall & Trewick 2008). The archipelago is approximately 1000 kilometers west of Ecuador and is the product of a stationary mantle hotspot (Morgan 1971); the

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[1] **Las plantas heterostilas que tiene dos formas de flores son definidas de doble estilo (Heterostylous plants having two flower morphs are termed distylous).**

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archipelago has never been in contact with any continental land mass. The ages of the individual islands increase eastward due to the movement of the Nazca plate on which the Galápagos are located (Rassmann 1997). From the velocity of the plate motion, scientists estimate that none of the islands above ocean level is older than five million years, and radiometric data predict a more recent origin of the present archipelago (White et al. 1993). The older islands are estimated to be between three and four million years old, while the younger islands may be one to two million years old (Hickman & Lipps 1985). The flora and fauna that dispersed to the Galápagos originated in various regions around the Pacific basin, including North, Central, and South America, the Caribbean, and Asia/Australasia (Grehan 2001; Jackson 1993). The climate of the Galápagos is extremely arid compared to most tropical archipelagos. The Islands experience a warm season from January to May, during which time lowland vegetation reaches its peak, and a cool season from June to December, where lowlands remain dry while highlands remain constantly wet from a mixture of light rain and mist (McMullen 1999).

Today, the Islands have a well-documented flora of 614 indigenous angiosperm species, of which 238 are endemic, 314 are native and 62 putatively so. The Islands also host 825 introduced species of which 324 are considered to be naturalized (McMullen 2011). The Galápagos Islands consist of three ecological zones that include the Littoral (Coastal) Zone, the Arid Lowlands, and the Moist Uplands (Johnson & Raven 1973). The Littoral Zone occupies the shoreline and is comprised of salt-tolerant vegetative species; the Arid Lowlands are characterized by *Opuntia* cacti and shrubby, herbaceous species that tolerate dry living conditions much of the year; the Moist Uplands are characterized by ferns, sedges, and evergreen tree species, including *Scalesia* (McMullen 1999). *Varronia* species from this study are primarily found in the Arid Lowlands, but may occasionally be found in the Moist Uplands.

Taxonomy and Phylogenetic History of Galapagos Varronia species

The angiosperm family Cordiaceae is represented in the archipelago by two genera, *Cordia* L. and *Varronia* P. Br., and seven species: *C. lutea* Lam., *C. alliodora* (Ruiz & Pav.) Oken, *V. polycephala* Lam., *V. canescens* Anderss., *V. leucophlyctis* (Hook. f.) Anderss., *V. revoluta* (Hook. f.) Anderss., and *V. scouleri* (Hook. f.) Anderss. (Jaramillo Díaz & Guézou 2011; Wiggins & Porter 1971). Of these seven, four are endemic (*V. canescens*, *V. leucophlyctis*, *V. revoluta*, and *V. scouleri*), with the remainder either native (*V. polycephala*) or introduced (*C. lutea*, *C. alliodora*). Until recently, all species were placed in the genus *Cordia*, but Miller and Gottschling (2007) resurrected the genus *Varronia* to circumscribe the monophyletic group of shrubby species limited to the Americas. *Varronia* species are multi-stemmed shrubs with regularly serrate leaf margins and have inflorescences that are condensed, capitate, spicate, or if cymose, then small and few-flowered; their pollen grains are porate. By contrast, *Cordia* species are single or few-stemmed trees with leaf margins that are entire or irregularly sharply dentate on the apical half and have inflorescences that are cymose; their pollen grains are colporate.

Varronia is an entirely New World genus with approximately 100 species ranging from Arizona to Argentina, with the predominance of the species being limited to the frost-free sub-tropics (Miller and Gottschling 2007). The presence of *Varronia* in the Galápagos is likely due to long-distance seed dispersal by frugivorous birds (McMullen 2009; Itow 2003) from western South America. Porter (1983) hypothesized that three of the endemic species of the "*leucophlyctis*-complex" (*V. canescens*, *V. leucophlyctis*, and *V. scouleri*) are most closely related to *V. macrocephala* Desv. (syn.= *V. polyantha* Benth.), a native of Columbia and Peru, and the findings of Weeks et al. (2010) are consistent with this hypothesis.

Of the four endemic species, *V. revoluta* is the most easily distinguished based on its linear, revolute leaves and tubular corolla. The three remaining endemic species are morphologically similar; these members of the so-called "*leucophlyctis*-complex" are quite difficult to distinguish reliably. The taxonomic key produced by Wiggins and Porter (1971) provides diagnoses based on leaf and calyx pubescence:

Leaves lanceolate, margins not revolute; corolla funnelform, the tube less than twice as long as width of limb; upper surface of leaves with erect or ascending hairs, not appressed-pubescent.
  Upper surface of leaves with both simple and stout, forked, or stellate and simple hairs with conspicuously pustulate bases; calyx lobes clothed with coarse simple and forked hairs much longer than those on lower part of cup_______ **V. canescens**
  Upper surface of leaves bearing only simple, erect or slightly curved, usually more slender hairs; calyx lobes with same-sized hairs as base of cup.

Stems and lower surface of leaves only stiff, erect, and simple hairs ____ **V. leucophlyctis**
Stems and lower surface of leaves bearing scattered, erect, simple hairs and a close cover of minute, appressed, stellate hairs ____ **V. scouleri**

In practice, however, their diagnoses do not cover the full range of *Varronia* species variation and do not provide the necessary separation needed for accurate and reliable identification.

Molecular phylogenetic data have not been able to fully resolve questions regarding the origin and evolution of the endemic *Varronia* species. Sequence data from the nuclear and chloroplast genomes indicate a possibly reticulate evolutionary history for the endemic species, with nuclear ribosomal DNA internal transcribed spacer (ITS) data supporting separate origins of *V. revoluta* and the species of the leucophlyctis-complex and chloroplast ndhF genic data supporting a single radiation event. Moreover, sequence data were not able to distinguish separate lineages within the complex. Fossil-based calibrations of the phylogeny indicate lineages are younger than some of the extant islands in the archipelago (< 4.5 Mya) and that the complex is likely less than 2 Mya. This finding suggests species boundaries may be difficult to distinguish because of the relative youth of this species complex (Weeks et al. 2010).

Rationale

The difficulty in distinguishing these endemic species may have conservation implications. Currently, the one endemic species easily identifiable, *V. revoluta*, is considered "Near Threatened" by the International Union for the Conservation of Nature (IUCN), whereas *V. scouleri* is considered "Vulnerable" (Tye 2000c,d). A Vulnerable species is one that has been categorized by the IUCN as likely to become endangered unless the circumstances threatening its survival and reproduction improve. A status of Near Threatened is assigned to a species that may be considered threatened with extinction in the near future, although it does not currently qualify for the Threatened status. Both *V. canescens* and *V. leucophlyctis* are classified as "Data Deficient" due to taxonomic uncertainty (Tye 2000a,b). Data Deficient is a category applied to a species when the available information, including abundance and distribution, is not sufficient for a proper assessment of conservation status to be made. Introduced species have become increasingly represented in the flora and fauna of the Galápagos Islands (Atkinson et al. 2010). The effects of these introduced species on the indigenous plants and animals of the archipelago must be monitored because so many of the species (39%) are endemic, such as the *Varronia* in this study (McMullen 2011). Because of the relatively unknown impact of introduced species on many endemic species, it is important to establish and maintain an accurately documented floral baseline for reference in future studies. Documentation of this sort, which includes updated nomenclature, taxonomic keys, and distribution maps, will provide useful information to Galápagos researchers, park personnel, and visiting researchers as they strive to develop sensible and effective conservation programs.

Objectives

The major objectives of this study were: 1) revise the nomenclature of the *Varronia* Galápagos endemics, 2) revise the leaf, trichome, and calyx lobe morphological descriptions for each *Varronia* species, and 3) produce a more reliable key for the endemic *Varronia* using characters that can be used in the field.

MATERIALS AND METHODS

A total of 348 herbarium specimens were examined: 133 specimens collected by CKM during trips to the Galápagos in 2005 and 2007 (JMUH) and an additional 215 loaned specimens collected between the years 1825 and 1983. A total of three specimens were obtained from the Brooklyn Botanic Garden (BKL), 49 from the California Academy of Sciences (CAS), eight from the New York Botanical Garden (NY), 56 from Harvard University (GH), 26 from the University of Copenhagen (C), 55 from the Swedish Museum of Natural History (S), and 18 from the Royal Botanic Gardens at Kew (K). Eight type specimens from K and one type specimen from S, as well as photographs of three type specimens from the University of Cambridge Herbarium (CGE) were studied for a total of 11 type specimens included in this study. A total of 81 specimens of *Varronia canescens*, 95 specimens of *V. leucophlyctis*, 89 specimens of *V. scouleri*, and 83 specimens of *V. revoluta* were examined.

Specimens were first sorted into piles based on relative similarities in leaf shape, regardless of the identification on the label. The specimens were then examined with a dissecting microscope and the piles were readjusted based on both leaf shape and morphological similarities in leaf pubescence. During this process, four distinct sets of morphological leaf shape and leaf pubescence characteristics were observed, as described in the following species narratives. In addition, measurements of leaf length and width on two leaves per specimen were taken, and observations of calyx length and pubescence were also observed. This information is also included in the species descriptions.

Endocarp structure of fruits from 17 different individuals was observed. Only JMUH specimens were utilized. Few specimens from other herbaria had fruits available, and most of these specimens were considerably older and in more fragile condition. Preparation of the endocarp included boiling fruits in distilled water for 15 minutes, and soaking them in a room temperature water bath for a 24-hour period to help loosen the fleshy material surrounding the endocarp. Any remaining material was removed with tweezers before observing the endocarp under a dissecting scope. Endocarp structure varied minimally between individuals observed, and was not useful in distinguishing species. This information is therefore not included in the new keys.

To obtain detailed images of the plants' leaf surface morphologies, a LEO 1340 VP Scanning Electron Microscope was used at the James Madison University SEM/EDS Regional Facility. The SEM operated with an acceleration voltage of 25 kV, a spot size of 300 (equivalent to a probe current of 102 picoamps), and a working distance of 25 mm. Samples of dried herbarium material were coated with gold from a sputter coater prior to imaging, and the images obtained are secondary electron images. The specimens selected to obtain SEM images were chosen as representative samples of the species based on observations with a dissecting microscope. In addition to work at James Madison University, a trip to the Galápagos Islands in February 2011 allowed direct observation of live specimens in the field, observation of herbarium specimens at the Charles Darwin Research Station (CDS), and field testing of the new taxonomic keys (Tables 1 and 2).

MORPHOLOGICAL CHARACTERIZATIONS

In the following species characterizations, all descriptions of leaf shape and size, leaf pubescence and color, and calyx pubescence and size at anthesis are the result of this morphological study. All other descriptions are from Wiggins and Porter (1971), and are cited as such within each description.

1. Varronia revoluta (Hook. f.) Andersson, Kongl. Vetensk.-Akad. Handl. 1853:204. 1855. ≡ *Cordia revoluta* Hook. f., Trans. Linn. Soc. London 20:199. 1847. TYPE: ECUADOR. GALÁPAGOS ISLANDS. Charles Island (Floreana Island): Sep 1835, *Charles Darwin s.n.* (HOLOTYPE: CGE 00287). ≡ *Lithocardium revolutum* (Hook. f.) Kuntze, Revis. Gen. Pl. 2:977. 1891. ≡ *Sebestena revoluta* (Hook. f.) Friesen, Bull. Soc. Bot. Genève 2(24):183. 1933, nom. illeg. ≡ *Varronia revoluta* (Hook f.) Borhidi, Acta Bot. Hung. 34:383. 1988, nom. illeg.

= *Cordia revoluta* Hook. f. var. *nigricans* Hook. f., Trans. Linn. Soc. London 20:199. 1847. TYPE: ECUADOR. GALÁPAGOS ISLANDS. Albemarle Island (Isabela Island): 1825, *Macrae s.n.* (LECTOTYPE, designated by Porter 1980: K 449166!; ISOLECTOTYPE: K 449167!).

= *Cordia linearis* Hook f., Trans. Linn. Soc. London 20:199. 1847, nom. illeg. TYPE: ECUADOR. GALÁPAGOS ISLANDS. James Island (Santiago Island): 1835, *Charles Darwin s.n.* (LECTOTYPE, designated by Porter 1980: CGE 00286; ISOLECTOTYPES: K 449161!, K 449162!). ≡ *Varronia linearis* (Hook. f.) Andersson, Kongl. Vetensk.-Akad. Handl. 1853:204. 1855. ≡ *Sebestena linearis* (Hook. f.) Friesen, Bull. Soc. Bot. Genève 2(24):182. 1933. ≡ *Lithocardium hookerianum* Kuntze, Revis. Gen. Pl. 2:976. 1891. ≡ *Cordia hookeriana* (Kuntze) Gürke, Nat. Pflanzenfam. 4(3):83. 1893.

Species description.—Varronia revoluta is a slenderly branched shrub 2–4 m in height, with dark gray-brown, shallowly fissured bark marked by transversely elliptic lenticels; young twigs densely fine-pubescent with appressed simple hairs (Wiggins & Porter 1971). Leaves linear with strongly revolute margins, 2.5–11.0 cm long, 0.2–1.0 cm wide; adaxial surfaces dark green and densely pubescent, hairs white, simple, and appressed (Fig. 1a); abaxial surfaces lighter green and densely villous pubescent, with more robust appressed hairs found on the veins; midrib is markedly elevated (Fig. 2a). Inflorescence globose-capitate on a slender, terminal peduncle 1.0–5.0 cm long with appressed-pubescence (Wiggins & Porter 1971). Calyx broadly cup-shaped to nearly globose, 2.5–3.5 mm long, about 3.0 mm wide, slightly contracted at apex, shallowly 5-lobed, only slightly

Table 1. A comparison of the diagnostic traits among the four species of endemic *Varronia* in the Galápagos Islands.

	V. revoluta	*V. leucophlyctis*	*V. canescens*	*V. scouleri*
leaf shape	linear	broadly lanceolate	lanceolate	lanceolate
leaf margins	revolute	finely serrate to crenate	finely serrate to crenate	coarsely serrate
adaxial leaf surface	hairs white and all simple appressed; densely pubescent	hairs mostly clear, erect and simple	hairs clear or white, typically appressed or sometimes weakly erect, stellate and forked, sometimes simple; hairs almost completely absent on some leaves	hairs mostly clear or white, erect simple, forked, sometimes stellate
abaxial leaf surface	hairs simple; densely villous pubescent; more robust, appressed white hairs on veins	hairs mostly simple and erect; often densely pubescent; simple, robust hairs common on veins; hairs generally clear or faintly white	hairs appressed stellate,forked, and simple; densely; pubescent hairs clear or white	hairs appressed stellate and forked, sometimes simple;sparsely pubescent; noticeably more robust hairs on veins; hairs generally clear or faintly white
calyx hairs	hairs simple; densely villous, uniform length throughout	hairs erect and simple; noticeably longer on calyx lobes than on calyx tube	hairs appressed stellate,forked, and simple, uniform length throughout	hairs erect and simple, sometimes forked or stellate; simple hairs noticeably longer on calyx lobes than on calyx tube
calyx lobes	much shorter than calyx tube at anthesis	about as long as calyx tube at anthesis	as long as or shorter than calyx tube at anthesis	usually longer than calyx tube at anthesis

Table 2. A dichotomous key to the four species of endemic *Varronia* in the Galápagos Islands.

1. Leaves linear.
    2. Leaf margins revolute; adaxial leaf hairs white and all simple appressed, densely pubescent; abaxial leaf hairs simple, densely villous pubescent, with more robust, appressed white hairs on veins; calyx hairs simple, densely villous, and uniform length throughout; calyx lobes much shorter than calyx tube at anthesis **V. revoluta**
1. Leaves lanceolate.
    3. Adaxial leaf hairs almost entirely erect and simple; abaxial leaf hairs mostly simple and erect, with robust, simple hairs found on veins.
        4. Leaf margins finely serrate to crenate calyx hairs erect and simple, noticeably longer on calyx lobes than on calyx tube; calyx lobes about as long as calyx tube at anthesis **V. leucophlyctis**
    3. Adaxial leaf hairs simple, forked, or stellate; abaxial leaf hairs simple, forked, or stellate.
        5. Leaf margins finely serrate to crenate; adaxial leaf hairs typically appressed or sometimes weakly erect, stellate and forked, sometimes simple; adaxial leaf hairs almost completely absent on some leaves; abaxial leaf hairs appressed stellate, forked, and simple, densely pubescent; calyx hairs appressed stellate, forked, and simple, uniform length throughout; calyx lobes as long as or shorter than calyx tube at anthesis **V. canescens**
        5. Leaf margins generally coarsely serrate; adaxial leaf hairs erect simple, forked, sometimes stellate; abaxial leaf hairs appressed stellate and forked, sometimes simple, sparsely pubescent, with noticeably more robust hairs on veins; calyx hairs erect and simple, sometimes forked or stellate, with simple hairs noticeably longer on calyx lobes than on calyx tube; calyx lobes usually longer than calyx tube at anthesis **V. scouleri**

turned outward in flower (Wiggins & Porter 1971); densely villous pubescent with simple hairs, uniform length throughout (Fig. 3a); calyx lobes much shorter than calyx tube at anthesis (Fig. 3a). Corolla white, usually 5-lobed (rarely 4), tubular, 7.0–12.0 mm long, 2.0–2.5 mm wide, with throat slightly narrowed, and lobes ascending-spreading to rotate (Wiggins & Porter 1971). See Wiggins and Porter (1971) for a more thorough description of the reproductive parts and fruits of this species.

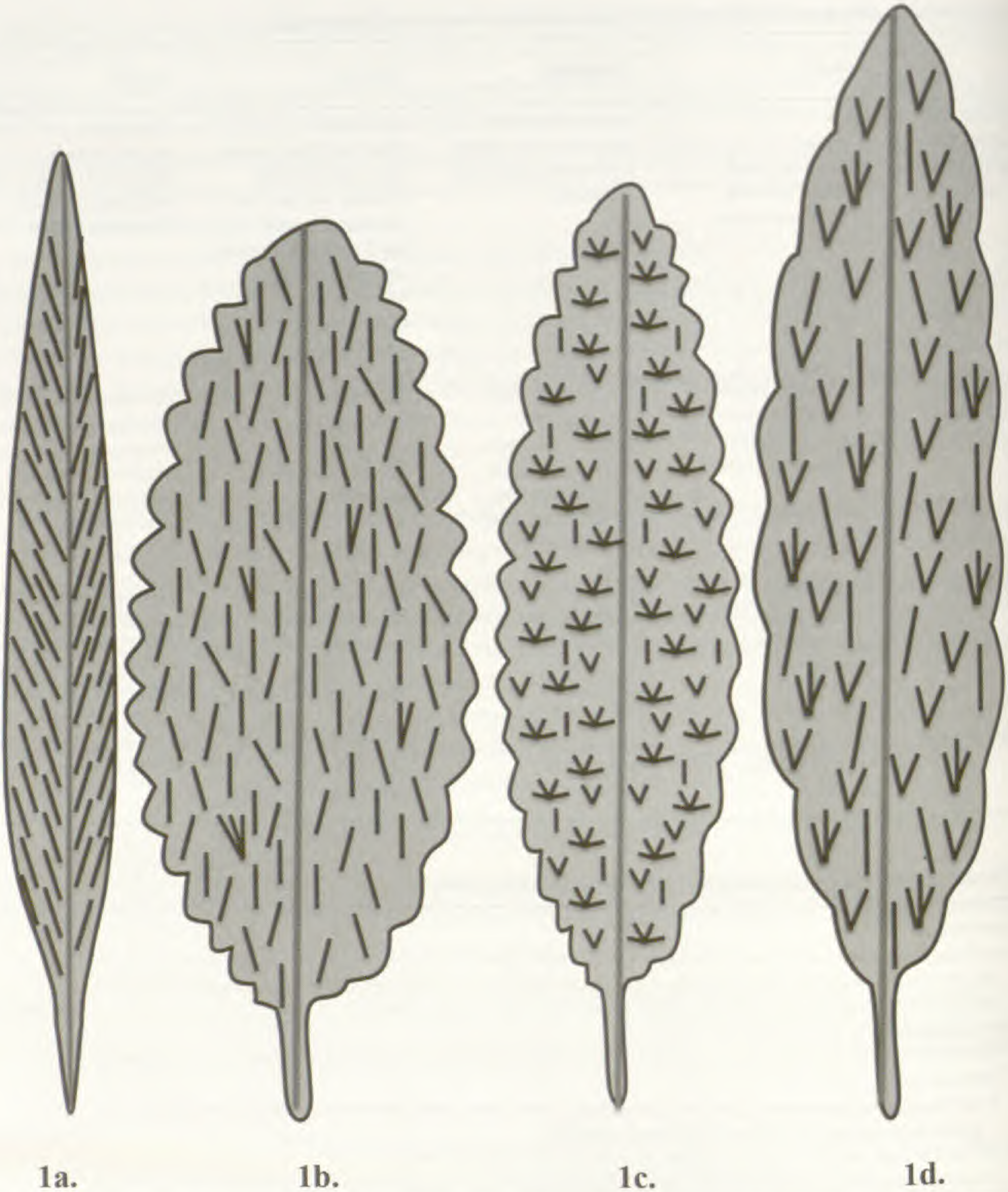

Fig. 1. Graphic representation of the variation in adaxial leaf surface hair types. **1a** represents *Varronia revoluta,* **1b** represents *Varronia leucophlyctis,* **1c** represents *Varronia canescens,* and **1d** represents *Varronia scouleri.*

Distribution and habitat.—Endemic to the Galápagos Islands. This species is found among other shrubs and in forests as an understory tree. It is also found on lava flows and rocky soil. It can be found at elevations from near sea level to 1420 m. Specimens have been collected from Fernandina, Floreana, Isabela, Santa Cruz, and Santiago Islands (Fig. 4).

Specimens examined. **ECUADOR. GALÁPAGOS ISLANDS. Fernandina Island:** Apr 1899, *R.E. Snodgrass and E. Heller 327* (GH 244027); Apr 1906, *Alban Stewart 3177* (CAS 27260, GH 244032); Feb 1964, *John R. Hendrickson 56* (CAS 619244); Feb 1964, *F.R. Fosberg 45099* (CAS 749292); Feb 1965, *D. Wiens 3825* (CAS 516647); Mar 1967, *Inga Eliasson 1700* (S s.n.). **Floreana Island:** Jul 2005, *Conley K. McMullen 839* (JMUH 13707); Jul 2005, *Conley K. McMullen 838* (JMUH 13705); Jul 2005, *Conley K. McMullen 837* (JMUH 13703); Jun 1891, *G. Baur 214* (GH 233528); May 1932, *John Thomas Howell 9372* (CAS 468109); Feb 1964, *Syuzo Itow 189* (CAS 579308); Oct 1905, *Alban Stewart 664* (CAS

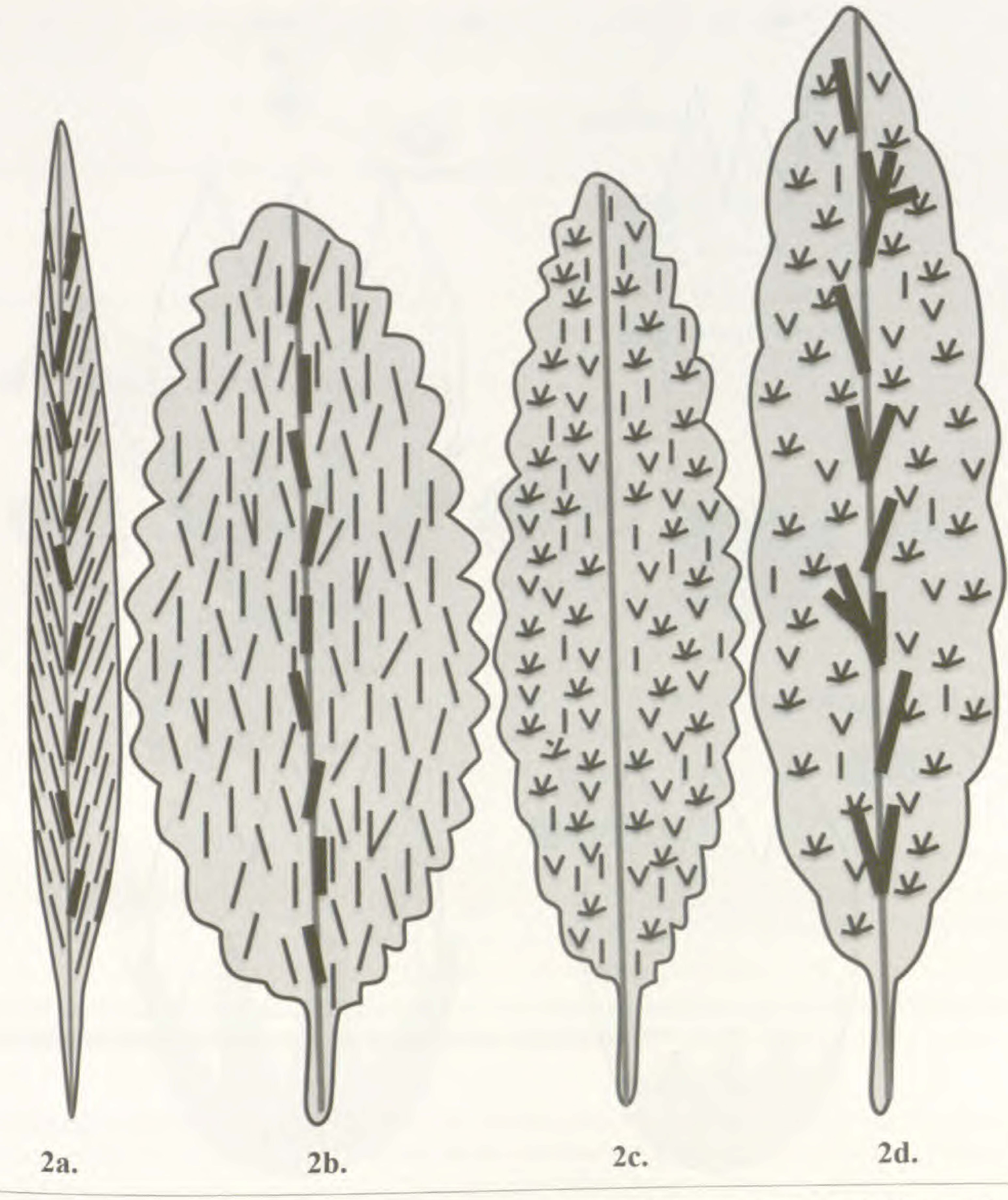

Fig. 2. Graphic representation of the variation in abaxial leaf surface hair types and positioning. **2a** represents *Varronia revoluta*, **2b** represents *Varronia leucophlyctis*, **2c** represents *Varronia canescens*, and **2d** represents *Varronia scouleri*.

694469); Feb 1967, *Ira L. Wiggins and Duncan M. Porter 555* (CAS 526365); Oct 1932, *H.J.F. Schimpff 215* (BKL 81339, NY s.n.); Dec 1966, *Inga Eliasson 785* (K H2007/01159/13, S s.n.); May 1967, *Inga Eliasson 2099* (S s.n.); Oct 1932, *H.J.F. Schimpff 215* (S s.n.). **Isabela Island:** Aug 2005, *Conley K. McMullen 850* (JMUH 13729); Aug 2005, *Conley K. McMullen 851* (JMUH 13732); Aug 2005, *Conley K. McMullen 852* (JMUH 13734); Aug 2005, *Conley K. McMullen 853* (JMUH 13736); Aug 2005, *Conley K. McMullen 860* (JMUH 13750); Aug 2005, *Conley K. McMullen 861* (JMUH 13752); Aug 2005, *Conley K. McMullen 862* (JMUH 13754); Aug 2005, *Conley K. McMullen 863* (JMUH 13756); Aug 2005, *Conley K. McMullen 849* (JMUH 849); Aug 2005, *Conley K. McMullen 848* (JMUH 13725); Jul 1891, *G. Baur 213* (GH 233529); Aug 1905, *Alban Stewart 3170* (GH 244034); Mar 1932, *John Thomas Howell 9465* (GH 244020); Jan 1967, *Ira L. Wiggins and Duncan M. Porter 207* (GH 244021); Jan 1899, *R.E. Snodgrass and E. Heller 155* (GH 244022); Mar 1899, *R.E. Snodgrass and E. Heller 196* (GH 244023); Feb 1899, *R.E. Snodgrass and E. Heller 272* (GH 244028); Aug 1905, *Alban Stewart 3169* (GH 244025); Mar 1906, *Alban Stewart 3173* (GH 244031); Jul 1891, *G. Baur 213* (GH 244035); Nov 1905, *Alban Stewart 3172* (GH 244033); Jun 1899, *R.E. Snodgrass and E. Heller 897* (GH 244030); Dec 1898, *R.E. Snodgrass and*

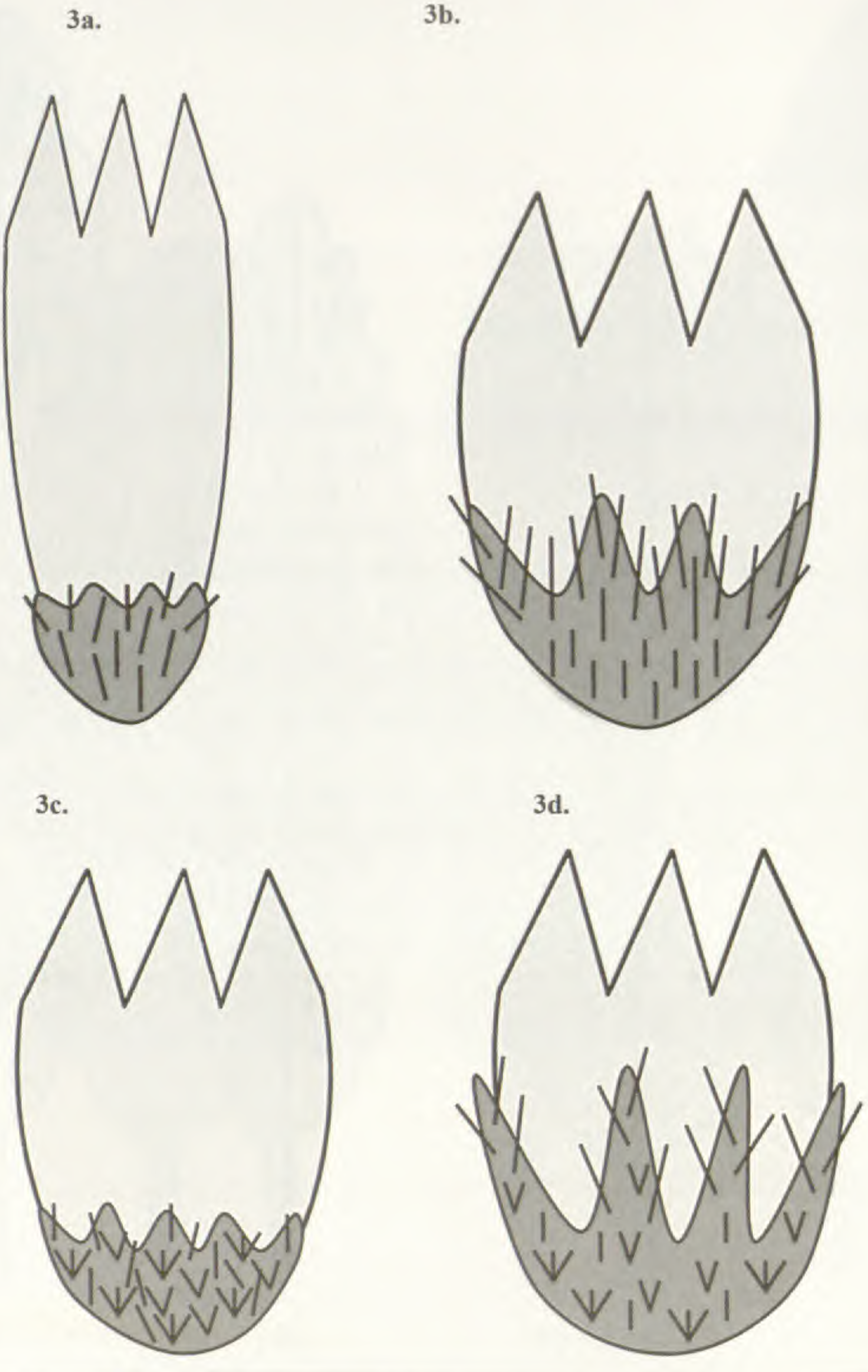

Fig. 3. Graphic representation of the variation in calyx lobe length in comparison to calyx tube length, and variation in calyx hair types. 3a represents *Varronia revoluta*, 3b represents *Varronia leucophlyctis*, 3c represents *Varronia canescens*, and 3d represents *Varronia scouleri*.

E. Heller 28 (GH 244019); Aug 1905, *Alban Stewart 3170* (CAS 27261); Apr 1974, *H.H. van der Werff 1025* (CAS 606128); Sep 1975, *H.H. van der Werff 2332* (CAS 606129); Jun 1963, *David Snow 289* (CAS 579303); Jan 1967, *Ira L. Wiggins and Duncan M. Porter 207* (CAS 525322); Jan 1967, *Ira L. Wiggins and Duncan M. Porter 231* (CAS 525339); May 1967, *Inga Eliasson 2196* (S s.n.); May 1967, *Inga Eliasson 2173* (S s.n.); Apr 1967, *Inga Eliasson 2013* (S s.n.); Mar 1967, *Inga Eliasson 1711* (S s.n.); Mar 1967, *Inga Eliasson 1548* (S s.n.); Feb 1967, *Inga Eliasson 1305* (S s.n.); Jun 1959, *Gunnar Harling 5357* (S s.n.); Jun 1959, *Gunnar Harling 5385* (S s.n.); 1825, *James Macrae s.n.* (K 449167); 1825, *James Macrae s.n.* (K 449166); Sep 1975, *H.H. van der Werff 2332*, (K H2007/01159/14). **Santa Cruz Island:** May 1932, *John Thomas Howell 9465* (NY s.n.). **Santiago Island:** Jul 1905, *Alban Stewart 3176* (GH 244026); Dec 1905, *Alban Stewart 3175* (GH 244024); Dec 1905, *Alban Stewart 3175* (CAS 27257); Oct 1835, *Charles Darwin s.n.* (K 449161); Oct 1835, *Charles Darwin s.n.* (K 449162).

Nomenclatural history.—*Varronia revoluta* is the most distinct of the four endemic *Varronia* species found on

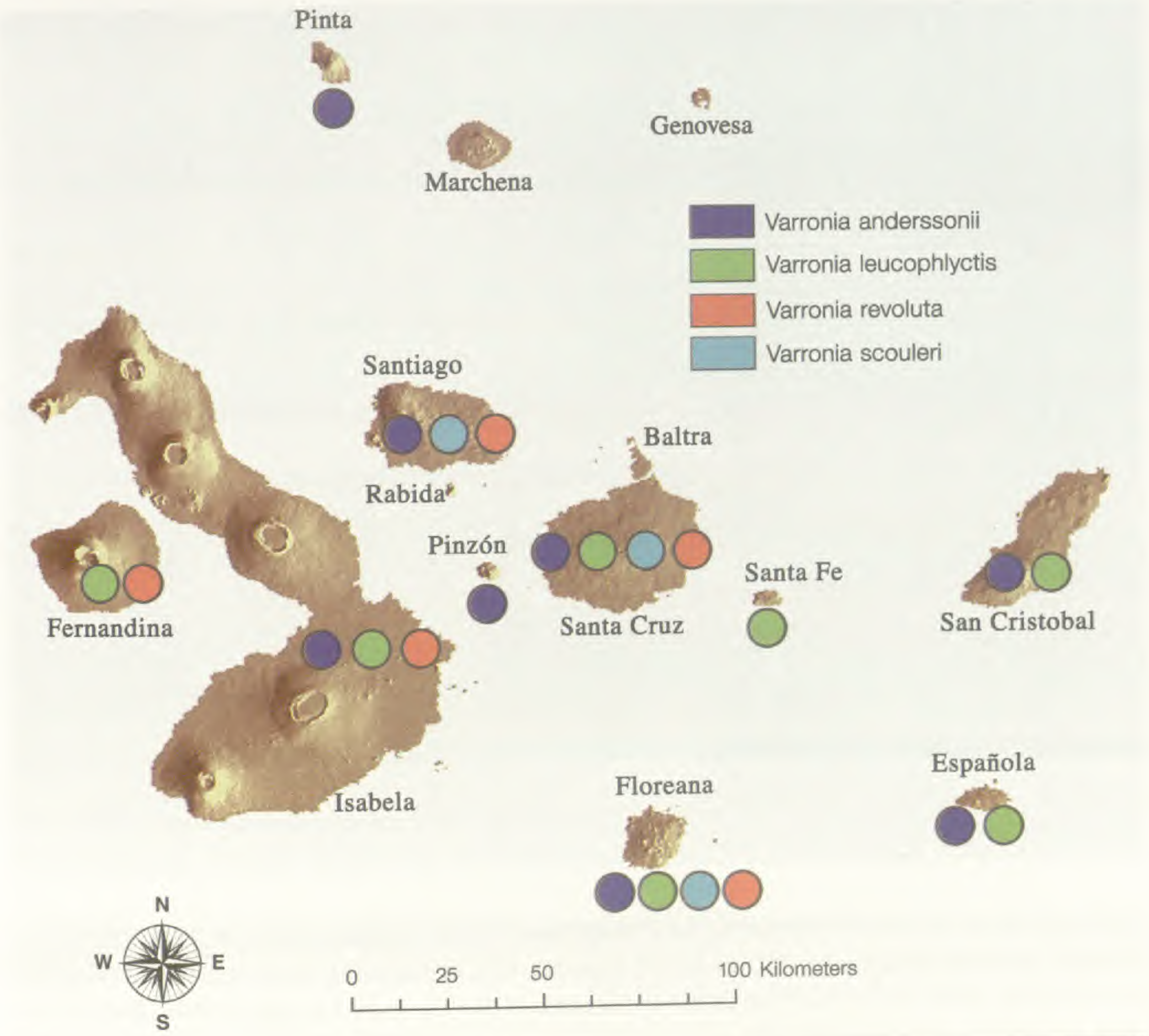
Pinta
Genovesa
Marchena
Varronia anderssonii
Varronia leucophlyctis
Varronia revoluta
Varronia scouleri
Santiago
Baltra
Rabida
Pinzón
Santa Fe
Fernandina
Santa Cruz
San Cristobal
Española
Floreana
Isabela
N
W
E
S
0
25
50
100 Kilometers

FIG. 4. Distribution of the four endemic *Varronia* species on the Galápagos Islands. The dots represent on which islands an individual species can be found, rather than a specific distribution on each island. No collections have been recorded for Marchena or Genovesa Islands.

the Galápagos Islands. Hooker first described this species in 1847 as *Cordia revoluta* Hook. f. In the same publication, Hooker also described *Cordia revoluta* Hook. f. var. *nigricans* Hook. f. and *Cordia linearis* Hook. f. Because *Cordia linearis* A.DC. was named in 1845, two years before Hooker, Hooker's *C. linearis* is not a validly published name (see Art. 45.3 and Art. 53.1, McNeill et al. 2006). Porter (1980) reviewed old specimens from Hooker, and though he did not discuss the taxonomy, he named *Macrae s.n.* (K 449166) as the lectotype of *Cordia revoluta* Hook. f. var. *nigricans* Hook. f. In observing this specimen, no obvious differences could be found between it and the other types, and it is therefore treated as a synonym in this study. Andersson (1855) transferred *C. revoluta* Hook. f. and *C. linearis* Hook. f. into *Varronia*. In 1891, Kuntze transferred *V. revoluta* (Hook. f.) Anderss. into *Lithocardium*, and in the same publication named a new species, *Lithocardium hookerianum* Kuntze. The type specimen for *L. hookerianum* Kuntze, which was housed in Leipzig (LZ), cannot be located and is presumed to have been destroyed with the herbarium in 1943 during a bombing raid in World War II (Thiers 2012). Gürke (1893) later transferred *L. hookerianum* into *Cordia*. In 1933, Friesen transferred *V. linearis* (Hook. f.) Anderss. and *C. revoluta* Hook. f. into *Sebestena*, without regard to Andersson's earlier renaming of *C. revoluta* Hook. f. as *V. revoluta* (Hook. f.) Anderss. and Kuntze's later reclassification to *Lithocardium revolutum* (Hook. f.) Kuntze. More recently Borhidi (1988) moved *Cordia revoluta* Hook. f. back into *Varronia* as

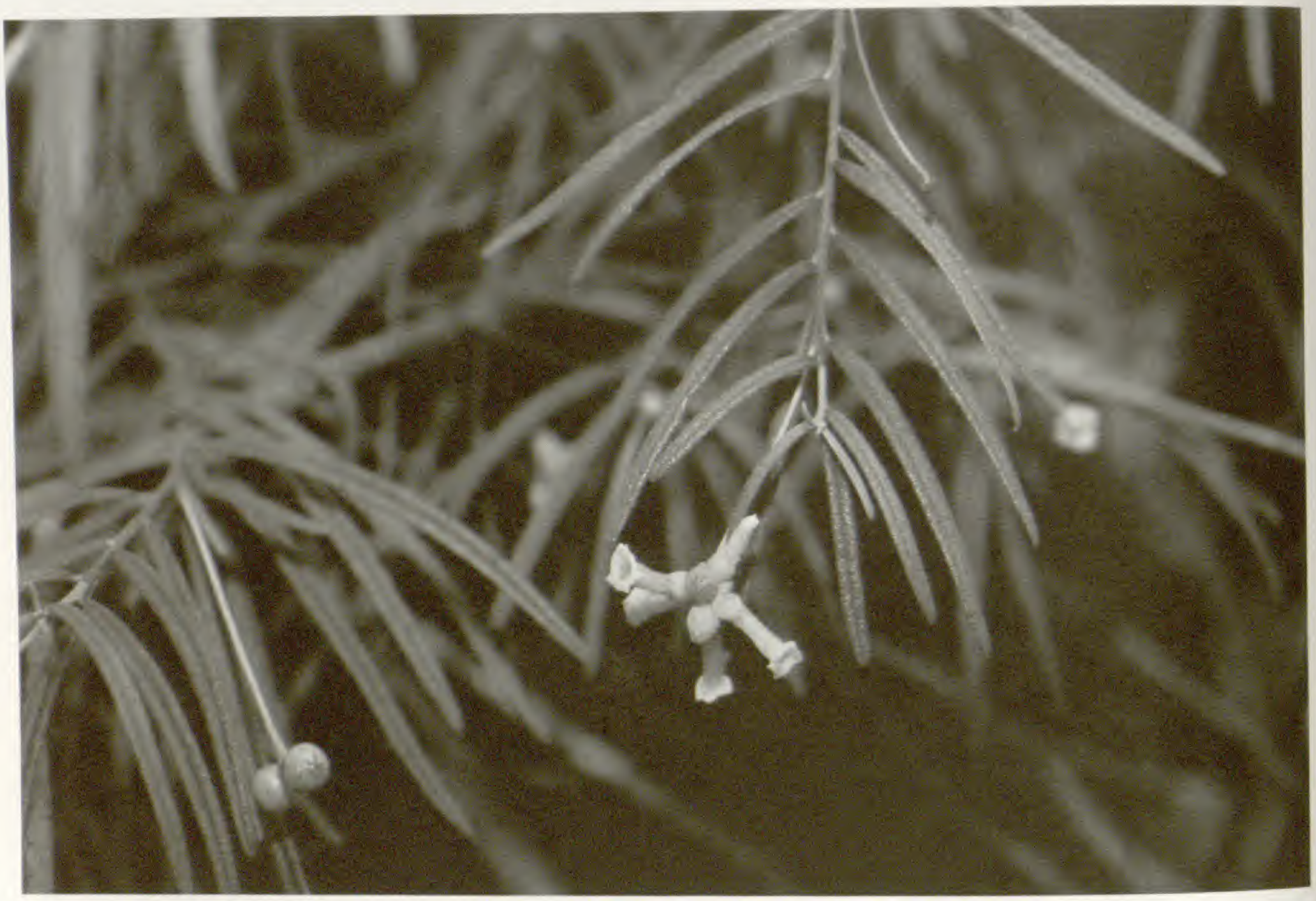

Fig. 5. View of a typical *Varronia revoluta* shrub displaying characteristic linear leaves and tubular flowers. Photograph courtesy of Conley K. McMullen. Specimen: Aug 2005, *Conley K. McMullen, 848* (JMUH 13725).

V. revoluta (Hook. f.) Borhidi without regard to Andersson's (1855) original nomenclature for the species. Therefore, Borhidi's change is invalid (see Art. 45.3 and Art. 53.1, McNeill et al. 2006). Recently, *Varronia* was resurrected by Miller and Gottschling (2007) and because of this, the name *Varronia revoluta* (Hook. f.) Anderss. has priority as the species name.

Contribution of this study.—After examining the types and other specimens, this species has distinctive linear leaves with revolute margins (Fig. 5), separating it from the other three Galápagos *Varronia*. *Varronia revoluta* also has very consistent leaf hairs that do not vary among the specimens examined. Adaxial leaf surfaces are densely pubescent with distinctive white, simple hairs that are appressed with tips oriented towards the leaf apex and/or outer margins (Fig. 6). Abaxial leaf surfaces also have simple, dense hairs. Margins are villous pubescent with simple hairs. More robust, appressed white hairs are found on the veins, which also bend towards the leaf apex/outer margins (Fig. 7). Calyxes are densely villous with simple hairs which are a uniform length throughout the entirety of the calyx. Calyx lobes are much shorter than the calyx tube at anthesis. The characters observed in this study agree with the description reported by Wiggins and Porter (1971). However, this study provides a more complete description of the leaf hairs, which are deemed to be the distinguishing features among the other three endemic Galápagos *Varronia* species.

2. **Varronia leucophlyctis** (Hook. f.) Andersson, Kongl. Vetensk.-Akad. Handl. 1853:203. 1855. ≡ *Cordia leucophlyctis* Hook. f., Trans. Linn. Soc. London 20:199. 1847. Type: ECUADOR. Galápagos Islands. Albemarle Island (Isabela Island): 1835, *Charles Darwin s.n.* (lectotype, designated by Porter 1980: CGE 00285). Paralectotypes: ECUADOR. Galápagos Islands. Albemarle Island (Isabela Island): 1825, *Macrae s.n.* (Porter 1980, K 449164!); no date, *Macrae s.n.* (Porter 1980, K 449163!). ≡ *Lithocardium leucophlyctis* (Hook. f.) Kuntze, Revis. Gen. Pl. 2:977. 1891.

= *Varronia scaberrima* Andersson, Kongl. Vetensk.-Akad. Handl. 1853:202. 1855, nom. illeg. Type: ECUADOR. Galápagos Islands. Indefatigable Island (Santa Cruz Island): 1853, *Andersson 220* (holotype: S 04-2351). ≡ *Lithocardium galapagosenum* Kuntze, Revis. Gen. Pl. 2:976. 1891. ≡ *Cordia galapagensis* (Kuntze) Gürke, Nat. Pflanzenfam. 4(3):83. 1893.

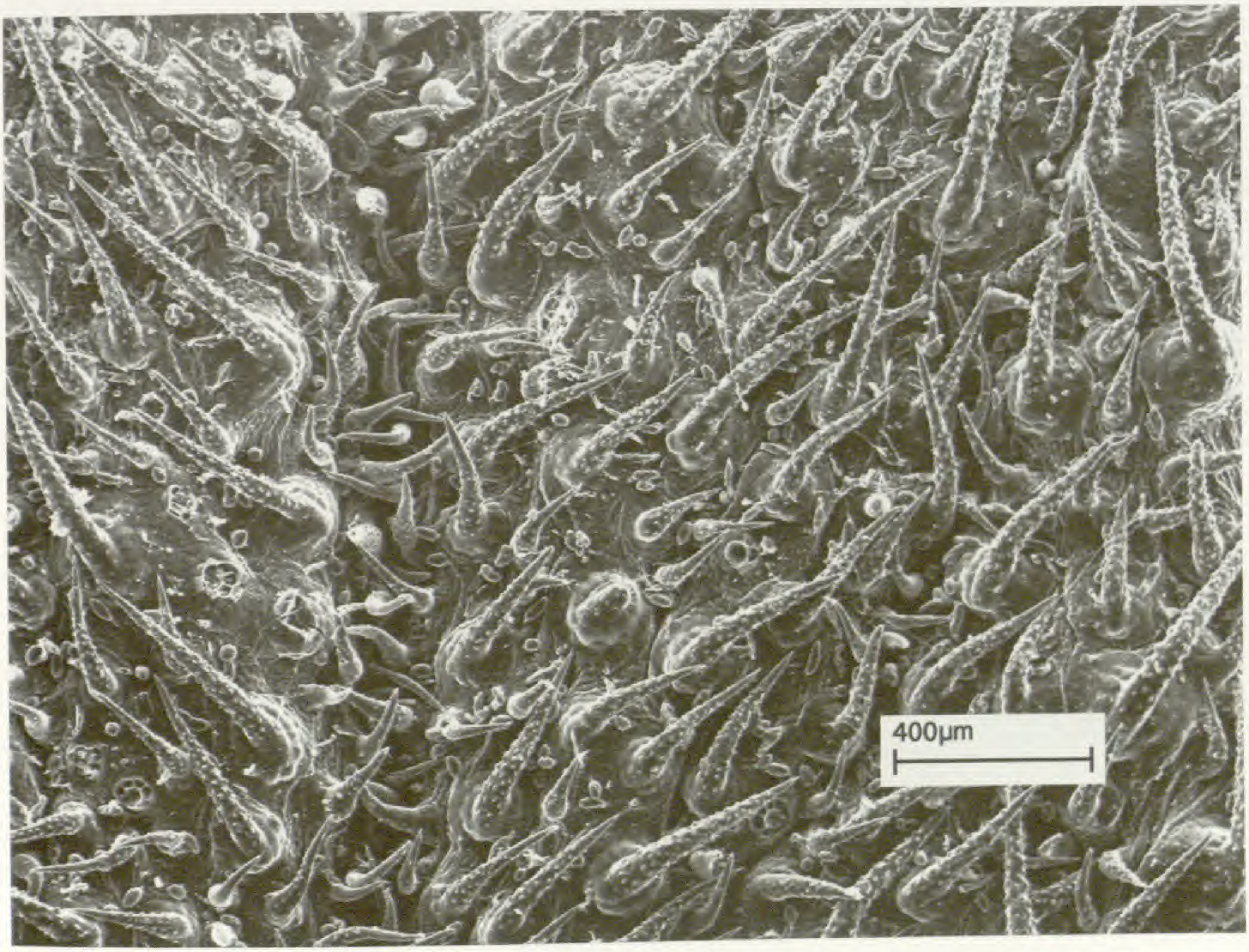

Fig. 6. ***Varronia revoluta*** **adaxial leaf surface displaying typical large, appressed simple hairs. Scale represents 400 µm. Specimen: Jul 2005,** ***Conley K. McMullen, 838*** **(JMUH 13705).**

Species description.—*Varronia leucophlyctis* is an open shrub 1.0–2.5 m tall, with one to several erect to ascending stems; bark dark brownish gray, with scattered, reddish tan, almost circular lenticels; young twigs, petioles, and peduncles densely pubescent with simple hairs (Wiggins & Porter 1971). Leaves broadly lanceolate, 2.0–11.0 cm long, 0.8–4.0 cm wide, with finely serrate to crenate margins; adaxial leaf surfaces dark green, pubescent with mostly erect and simple hairs (Fig. 1b); abaxial leaf surfaces lighter green, often densely pubescent, with erect, mostly simple hairs; simple hairs on veins are commonly robust (Fig. 2b). Inflorescence capitate to short-spicate, on terminal peduncles 1.0-5.0 cm long (Wiggins & Porter 1971). Calyx broadly cup-shaped to narrowly campanulate, 6.0 mm long, 4.0 mm wide, 4- or 5-lobed (Wiggins & Porter 1971); calyx lobes about as long as calyx tube at anthesis (Fig. 3b); calyx pubescent with erect and simple hairs that are noticeably longer on calyx lobes than calyx tube (Fig. 3b). Corolla white, usually 5-lobed, funnelform, tube 7.0–8.0 mm long, 7.0–8.0 mm wide; lobes rotate-spreading to slightly reflexed (Wiggins & Porter 1971). See Wiggins and Porter (1971) for a more thorough description of the reproductive parts and fruits of this species.

Distribution and habitat.—Endemic to the Galápagos Islands. This species is found among lava boulders and in rocky soil among other shrubs. It is also sometimes found as an understory shrub in forested areas. Found from near sea level to 1750 m. Specimens have been collected from Española, Fernandina, Floreana, Isabela, San Cristobal, Santa Cruz, and Santa Fe Islands (Fig. 4).

Specimens examined. **ECUADOR. GALÁPAGOS ISLANDS. Española Island:** Feb 1906, *Alban Stewart 3168* (GH 244016); Feb 1906, *Alban Stewart 3168* (CAS 27273). **Fernandina Island:** Mar 1899, *R.E. Snodgrass and E. Heller 342* (CAS 9251, GH 244008); Apr 1899, *R.E. Snodgrass and E. Heller 331* (GH 233533); Mar 1967, *Inga Eliasson 1701* (S s.n.); Sep 1972, *A.E.P. Schmidt 2535* (C 24/2007/26); Jan 1972, *Michelle and Ole Hamann 222* (C 24/2007/22). **Floreana Island:** Jul 2005, *Conley K. McMullen 840* (JMUH 13708); Jul 2005, *Conley K. McMullen 844* (JMUH

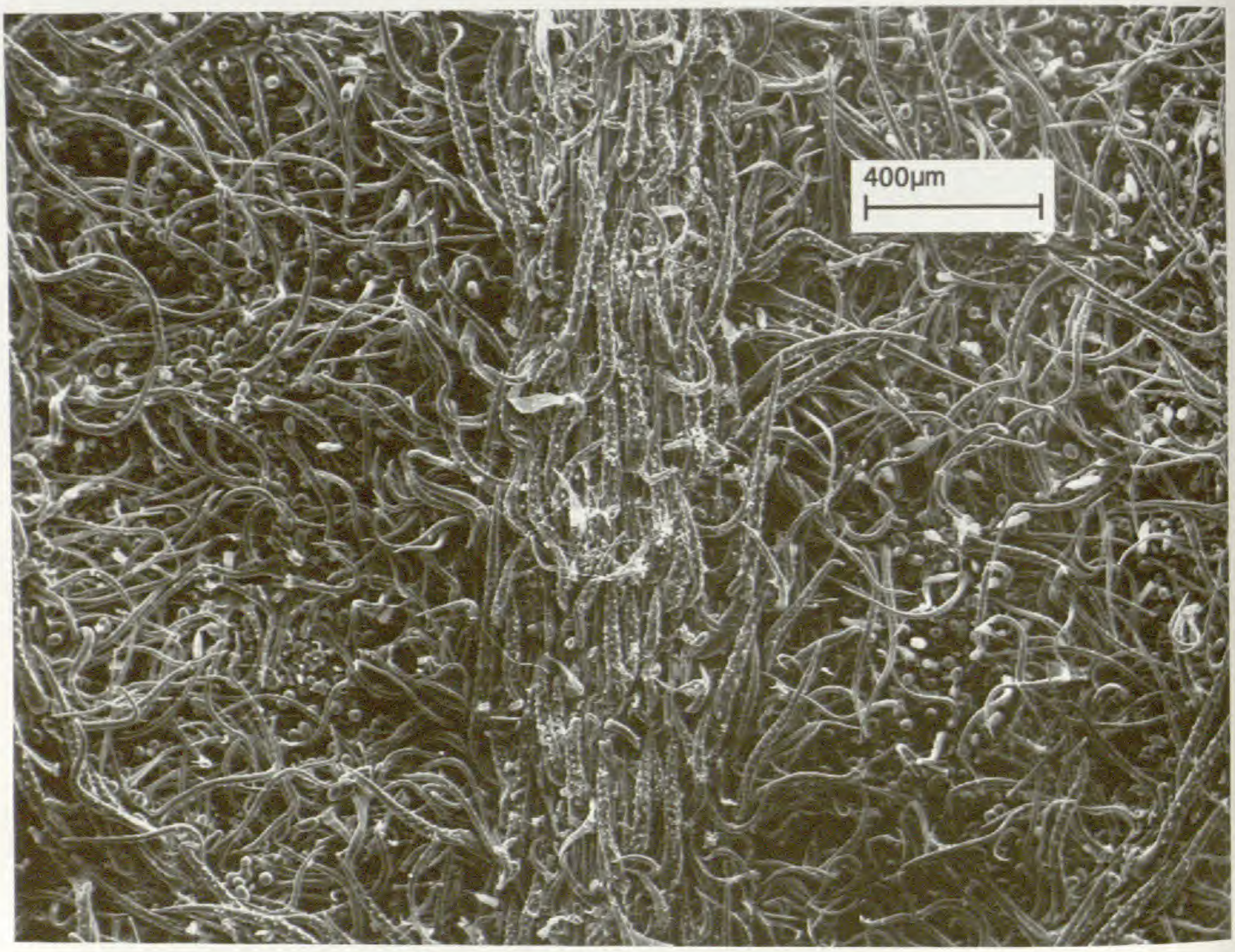

Fig. 7. ***Varronia revoluta*** **abaxial leaf surface displaying robust appressed simple hairs on veins, and densely villous simple hairs in margins. Scale represents 400 µm. Specimen: Jul 2005,** ***Conley K. McMullen, 838*** **(JMUH 13705).**

13716); Dec 1966, *Inga Eliasson 824* (S s.n.); Dec 1966, *Inga Eliasson 813* (S s.n.); Dec 1966, *Inga Eliasson 904* (S s.n.); Dec 1966, *Inga Eliasson 877* (S s.n.). **Isabela Island:** Aug 2005, *Conley K. McMullen 859* (JMUH 13748); Aug 2005, *Conley K. McMullen 857* (JMUH 13745); Aug 2005, *Conley K. McMullen 856* (JMUH 13743); Aug 2005, *Conley K McMullen 858* (JMUH 13747); Aug 2005, *Conley K. McMullen 854* (JMUH 13739); Mar 2007, *Conley K McMullen and Michael Shane Woolf 881* (JMUH 13797); Mar 2007, *Conley K. McMullen and Michael Shane Woolf 877* (JMUH 13788); Mar 2007, *Conley K. McMullen and Michael Shane Woolf 878* (JMUH 13790); Mar 2007, *Conley K. McMullen and Michael Shane Woolf 879* (JMUH 13792); Mar 2007, *Conley K. McMullen and Michael Shane Woolf 880* (JMUH 13794); Mar 1906, *Alban Stewart 3159* (GH 244014); Mar 1906, *Alban Stewart 3164* (GH 233526); Mar 1899, *R.E. Snodgrass and E. Heller 195* (GH 244007); Feb 1899, *R.E. Snodgrass and E. Heller 291* (GH 233534); Jun 1899, *R.E. Snodgrass and E. Heller 893* (CAS 9260, GH 244011); Jun 1899, *R.E. Snodgrass and E. Heller 857* (GH 244013); Jun 1899, *R.E. Snodgrass and E. Heller 881* (GH 244012); Aug 1891, *G. Baur 212* (GH 233532); Jul 1891, *G. Baur 210* (GH 233530); no date, *R.E. Snodgrass and E. Heller 136* (GH 244009); Dec 1898, *R.E. Snodgrass and E. Heller 75* (GH 244010); Apr 1932, *John Thomas Howell 8976* (CAS 468107); Mar 1906, *Alban Stewart 3161* (CAS 27270); Jan 1967, *Ira L. Wiggins and Duncan M. Porter 232* (K H2007/01159/9, CAS 525340); Mar 1906, *Alban Stewart 3160* (CAS 27272); May 1932, *John Thomas Howell s.n.* (CAS 468103); May 1932, *John Thomas Howell 9431* (CAS 468111); Apr 1974, *H.H. van der Werff 1037* (CAS 606063); Apr 1974, *H.H. van der Werff 1033* (CAS 606062); Jun 1959, *Gunnar Harling 5622* (S s.n.); Jun 1959, *Gunnar Harling 5360* (S s.n.); Jun 1959, *Gunnar Harling 5312* (S s.n.); Apr 1967, *Inga Eliasson 2034* (S s.n.); Mar 1967, *Inga Eliasson 1713* (S s.n.); May 1967, *Inga Eliasson 2219* (S s.n.); May 1967, *Inga Eliasson 2208* (S s.n.); Feb 1967, *Inga Eliasson 1285* (S s.n.); Feb 1967, *Inga Eliasson 1303* (S s.n.); Sep 1972, *Michelle and Ole Hamann 2243* (C 24/2007/24); Jul 1972, *Michelle and Ole Hamann 1780* (C 24/2007/20); Jul 1972, *Michelle and Ole Hamann 1771* (C 24/2007/19); Jul 1972, *Michelle and Ole Hamann 1709* (C 24/2007/18); Jul 1972, *Michelle and Ole Hamann 1615* (C 24/2007/17); Sep 1972, *Michelle and Ole Hamann 2320* (C 24/2007/12); 1825, *James Macrae s.n.* (K 449163); 1825, *James Macrae s.n.* (K 449164); Apr 1932, *John Thomas Howell 8976* (K H2007/01159/15). **San Cristobal Island:** Feb 1967, *Ira L. Wiggins and Duncan M. Porter 379* (CAS 526675, GH 233549). **Santa Cruz Island:** Apr 1930, *H.K. Svenson 7* (GH 233525-1); Feb 1964, *Ira L. Wiggins 18485* (CAS 619426, GH 244006); Aug 1891, *G. Baur 211* (GH 233531); Mar 1938, *C.M. Haggs 21* (CAS 262726); Mar 1935, *J.P. Chapin 1125* (BKL 81351, NY s.n.); May 1981, *C. Grady Walker 568* (NY s.n.); Apr 1967, *Inga Eliasson 1940* (S s.n.); Apr 1967, *Inga Eliasson 1919* (S s.n.); Nov 1966, *Inga Eliasson 514* (S s.n.); Apr 1972, *P. Pritchard 1197* (C 24/2007/13); Mar 1981, *O. Hamann and O. Seberg 1772b* (C 24/2007/16); Mar

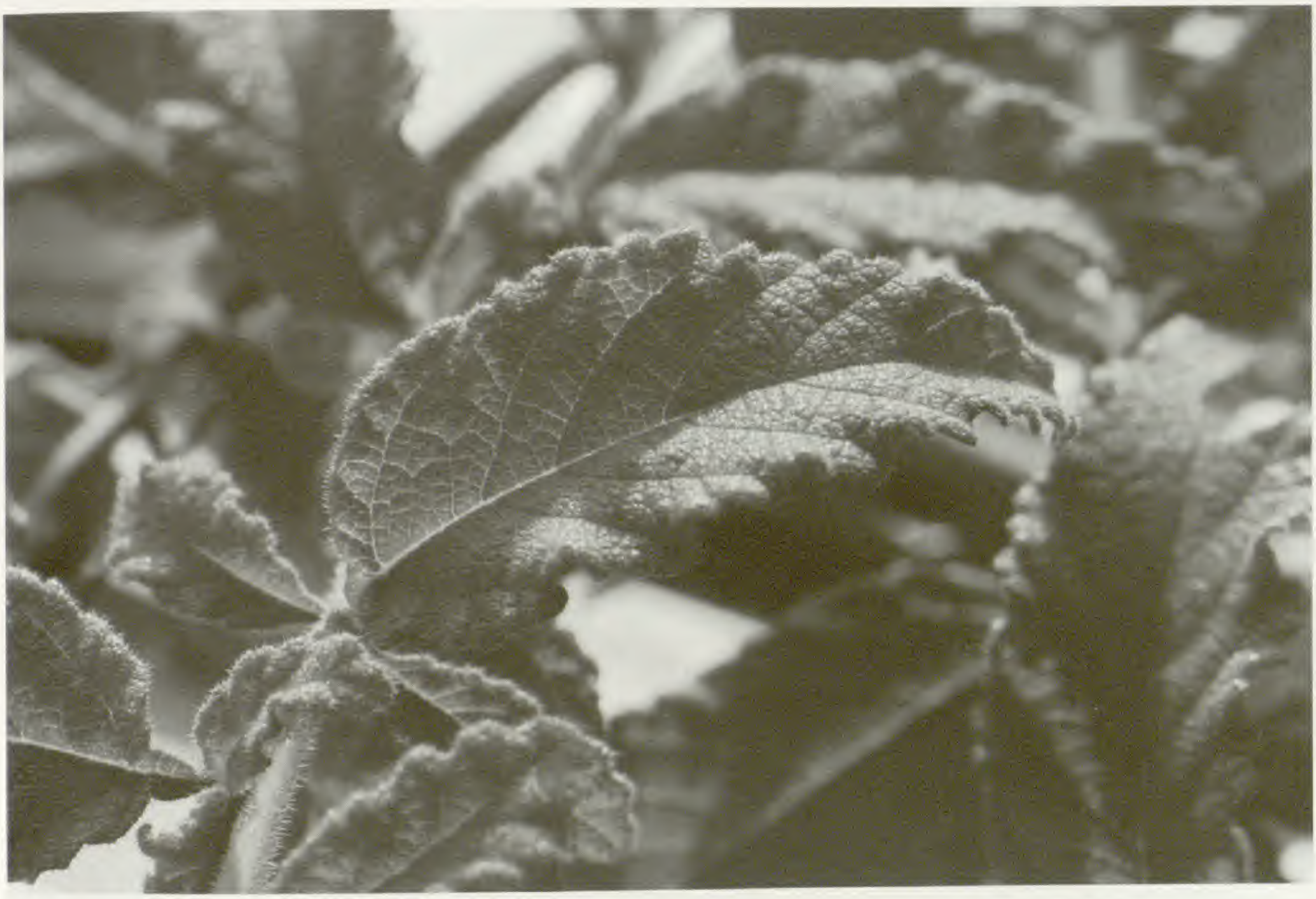

Fig. 8. View of a typical *Varronia leucophlyctis* lanceolate leaf with crenate margins. Photograph courtesy of Conley K. McMullen. Specimen: Mar 2007, *Conley K McMullen and Michael Shane Woolf, 881* (JMUH 13797).

1981, *O. Seberg 1746* (C 24/2007/15). **Santa Fe Island:** Oct 1905, *Alban Stewart 3164* (CAS 27266, GH 244015); Feb 1972, *Michelle and Ole Hamann 463* (C 24/2007/21).

Nomenclatural history.—Hooker (1847) first described this species as *Cordia leucophlyctis* Hook. f., moved by Andersson (1855) into *Varronia*, then transferred into *Lithocardium* by Kuntze (1891). In 1855, Andersson described a new species, *Varronia scaberrima* Anderss.; however, as *Varronia scaberrima* Bert. ex Spreng. was already in existance, *V. scaberrima* Anderss. is not valid (see Art. 45.3 and Art. 53.1, McNeill et al. 2006). In 1891, Kuntze moved both *Varronia* P. Br. and *Cordia* L. into *Lithocardium* Kuntze; however, Kuntze renamed *V. scaberrima* as *Lithocardium galapagosenum* Kuntze, because the epithet "*scaberrima*" was already occupied by *L. scaberrima*, which had priority. *Lithocardium galapagosenum* was later moved by Gürke (1893) into *Cordia*, and was considered taxonomically synonymous to *Cordia leucophlyctis* by Wiggins and Porter (1971). Miller and Gottschling's (2007) resurrection of the genus *Varronia* makes *Varronia leucophlyctis* (Hook. f.) Anderss. the correctly recognized name for this species.

Contribution of this study.—The leaves of *V. leucophlyctis* tend to be distinct from those of either *V. canescens* or *V. scouleri*. The leaf shape tends to be broadly lanceolate with finely serrate to crenate margins (Fig. 8), but this is not entirely consistent among the specimens examined. However, as with *V. revoluta*, *V. leucophlyctis* has mostly consistent hair types across all of the examined specimens. Adaxial leaf surface hairs are mostly erect and simple (Fig. 9). Abaxial leaf surfaces are often densely pubescent, with mostly simple, erect hairs; simple, larger hairs can be found on the veins (Fig. 10). Very rarely, forked or stellate hairs may be found on either leaf surface of *V. leucophlyctis*. Calyx hairs are also erect and simple, and noticeably longer on the calyx lobes that on the calyx tube. The calyx lobes themselves are about as long as the calyx tube at anthesis.

Though leaf morphology of this species is often distinct, *V. leucophlyctis* can still be confused with both *V. canescens* and *V. scouleri*. In this situation, the hairs on the adaxial and abaxial leaf surfaces are the best char-

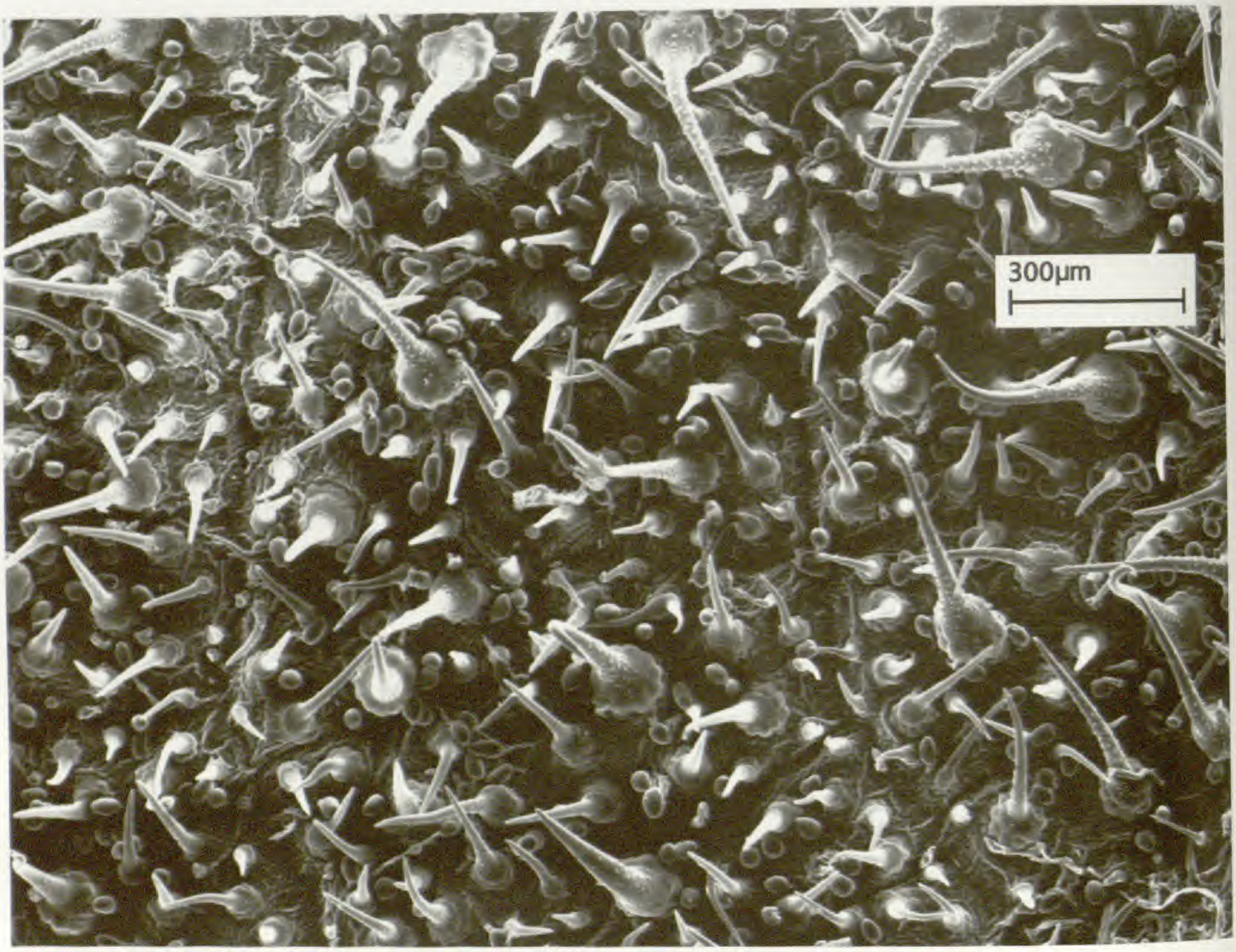

Fig. 9. ***Varronia leucophlyctis*** **adaxial leaf surface displaying erect, simple hairs. Scale represents 300 µm. Specimen: Jul 2005,** ***Conley K. McMullen, 844*** **(JMUH 13716).**

acter to use for identification. Neither *V. canescens* nor *V. scouleri* possesses predominately simple, erect hairs on both leaf surfaces, and in the same abundance as found on *V. leucophlyctis*.

3. Varronia canescens Andersson, Kongl. Vetensk.-Akad. Handl. 1853:203. 1855. Type: ECUADOR. Galápagos Islands. Charles Island (Floreana Island): 1853, *Andersson s.n.* (holotype: S 04-1959!).

= *Lithocardium anderssonii* Kuntze, Revis. Gen. Pl. 2:976. 1891. ≡ *Cordia anderssonii* (Kuntze) Gürke, Nat. Pflanzenfam. 4(3):83. 1893. ≡ *Varronia anderssonii* (Kuntze) Borhidi, Acta Bot. Hung. 34:383. 1988, nom. illeg.

Species description.—Varronia canescens is an erect, moderately branched shrub 1.0–3.0 m tall, with one to several stems from the base; bark dark brown and thin (Wiggins & Porter 1971). Young twigs densely pubescent with appressed stellate, forked, and simple hairs. Leaves lanceolate, 1.3–11.8 cm long, 0.5–4.3 cm wide, with finely serrate to crenate margins; adaxial leaf surfaces dark green, glabrous to sparsely pubescent with hairs typically appressed or sometimes weakly erect, stellate and forked, sometimes simple (Fig. 1c); abaxial leaf surfaces lighter green, densely pubescent with appressed stellate, forked, and simple hairs (Fig. 2c). Inflorescence subcapitate to short-spicate, on slender peduncles, 1.5–10.0 cm long (Wiggins & Porter 1971). Calyx narrowly campanulate, 3.0–5.0 mm long, 4- or 5-lobed (Wiggins & Porter 1971); calyx lobes as long as or shorter than calyx tube at anthesis (Fig. 3c); calyx appressed pubescent with stellate, forked, and simple hairs, generally uniform length throughout (Fig. 3c). Corolla white, 5-lobed, funnelform, tube 5.0–8.0 mm at anthesis, lobes rotate-spreading to reflexed (Wiggins & Porter 1971). See Wiggins and Porter (1971) for a more thorough description of the reproductive parts and fruits of this species.

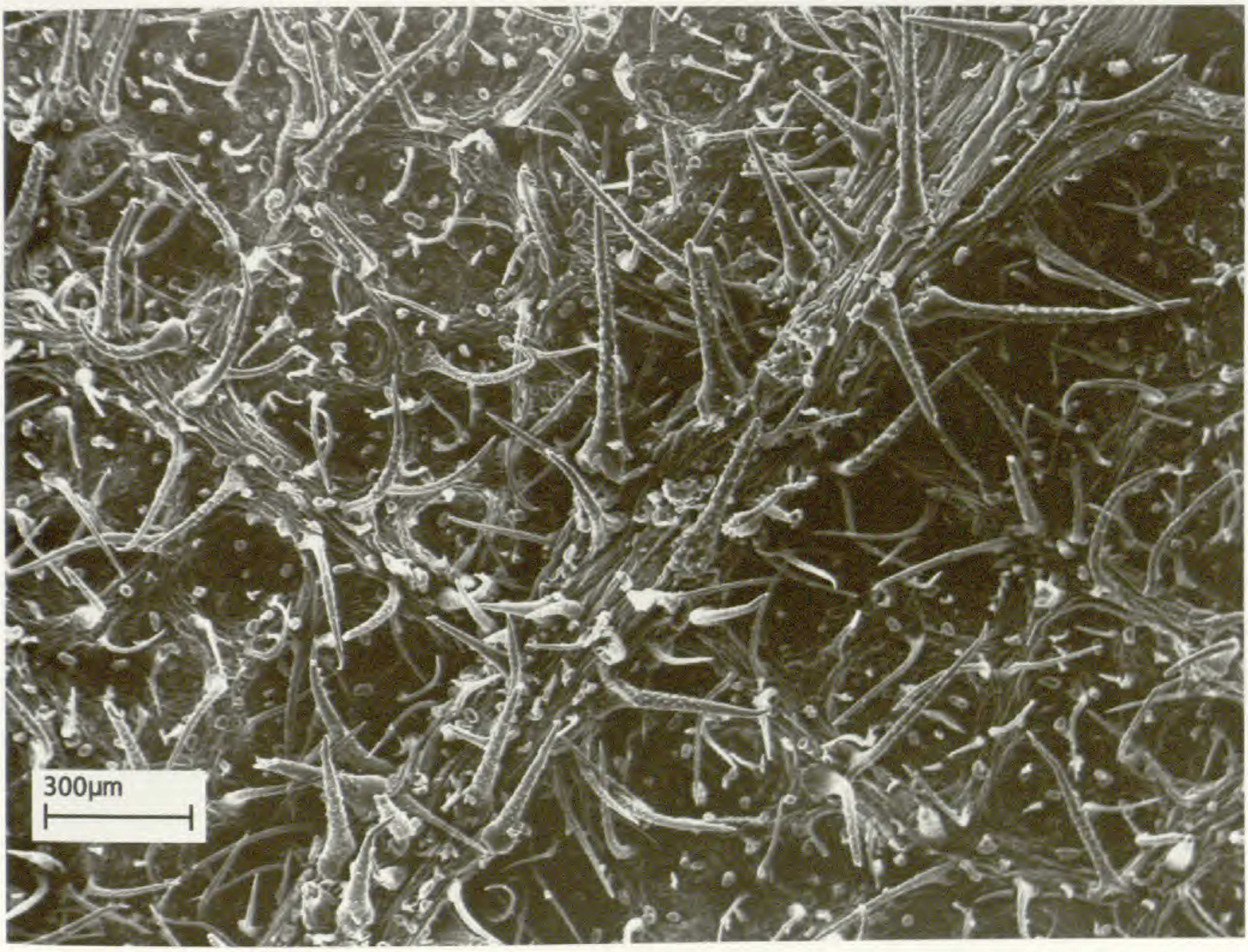

Fig. 10. *Varronia leucophlyctis* abaxial leaf surface displaying robust, erect simple hairs on veins, and simple hairs in margins. Scale represents 300 µm. Specimen: Mar 2007, *Conley K. McMullen and Michael Shane Woolf, 880* (JMUH 13794).

Distribution and habitat.—Endemic to the Galápagos Islands. This species is found among lava boulders and in rocky soil among other shrubs. It is also sometimes found as an understory shrub in forested areas. Found from near sea level to 950 m. Specimens have been collected from Española, Floreana, Isabela, Pinta, Pinzón, San Cristobal, Santa Cruz, and Santiago Islands (Fig. 4). This species is the most widely distributed of the endemic Galápagos *Varronia*.

Specimens examined. **ECUADOR. GALÁPAGOS ISLANDS. Española Island:** Feb 1964, *C.B. Koford 24* (CAS 619350); Apr 1932, *John Thomas Howell 8706* (CAS 468106). **Floreana Island:** Jul 2005, *Conley K. McMullen 841* (JMUH 13710); Jul 2005, *Conley K. McMullen 842* (JMUH 13712); Jul 2005, *Conley K. McMullen 843* (JMUH 13714); 1853, *Andersson s.n.* (GH 233538); Apr 1888, *Leslie A. Lee s.n.* (GH 233547); 1853, *Andersson s.n.* (S S04-1959); Dec 1966, *Inga Eliasson 826* (S s.n.); Jun 1972, *Michelle and Ole Hamann 1423* (C 24/2007/10). **Isabela Island:** Aug 1905, *Alban Stewart 3195* (CAS 27276, GH 233543, NY *s.n.*). **Pinta Island:** Sep 1905, *Alban Stewart 3158* (CAS 27267, GH 233542); Mar 1972, *Michelle and Ole Hamann* 869 (C 24/2007/6); Mar 1972, *Michelle and Ole Hamann 920* (C 24/2007/1); May 1964, *David Snow 589* (K H2007/01159/16); 1868, *Habel s.n.* (K H2007/01159/17). **Pinzón Island:** Aug 1891, *G. Baur 215* (GH 244002); May 1970, *Syuzo Itow 51409-1* (CAS 623521); Aug 1905, *Alban Stewart 3167* (CAS 27274); Jan 1967, *Inga Eliasson 1046* (S s.n.); Jan 1967, *Inga Eliasson 1042* (S s.n.); May 1972, *Michelle and Ole Hamann 1250* (C 24/2007/5). **San Cristobal Island:** Mar 2007, *Conley K. McMullen and Michael Shane Woolf 882* (JMUH 13799); Mar 2007, *Conley K. McMullen and Michael Shane Woolf 883* (JMUH 13802); Mar 2007, *Conley K. McMullen and Michael Shane Woolf 884* (JMUH 13804); Mar 2007, *Conley K. McMullen and Michael Shane Woolf 885* (JMUH 13806); Mar 2007, *Conley K. McMullen and Michael Shane Woolf 886* (JMUH 13809); Jul 2005, *Conley K. McMullen 830* (JMUH 13688); Jul 2005, *Conley K. McMullen 824* (JMUH 13675); Jul 2005, *Conley K. McMullen 825* (JMUH 13677); Jul 2005, *Conley K. McMullen 826* (JMUH 13679); Jul 2005, *Conley K. McMullen 827* (JMUH 13681); Jul 2005, *Conley K. McMullen 828* (JMUH 13684); Jul 2005, *Conley K. McMullen 829* (JMUH 13685); Jun 1891, *G. Baur 216* (GH 233523); no date, *Andersson s.n.* (GH 233539); Feb 1906, *Alban Stewart 3165* (CAS 27265, GH 233540); Feb 1906, *Alban Stewart 3166* (GH 233541); no date, *F. Fagerlind and G. Wibom s.n.* (S s.n.); no date, *F. Fagerlind and G. Wibom 2753* (S s.n.); Apr 1967, *Inga Eliasson 1848* (S s.n.); no date, *Andersson s.n.* (S s.n.); no date, *Andersson 222* (S s.n.); 1853, *Andersson s.n.* (S s.n.); Jun 1959, *Gunnar Harling 5652* (S s.n.). **Santa Cruz**

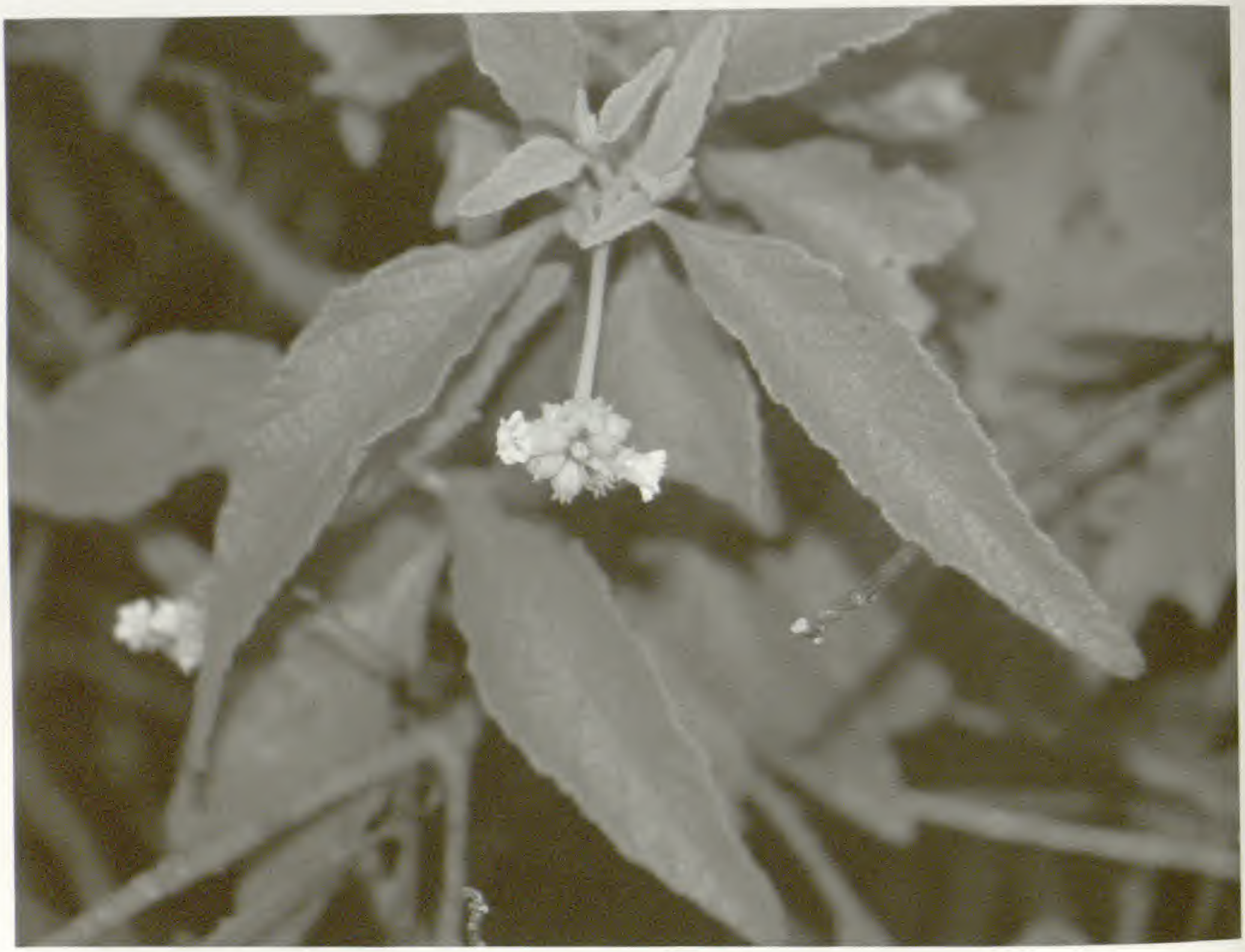

Fig. 11. View of typical *Varronia canescens* lanceolate leaves with crenate margins. Photograph courtesy of Conley K. McMullen. Specimen: Mar 2007, *Conley K. McMullen and Michael Shane Woolf, 884* (JMUH 13804).

Island: Dec 1966, *Inga Eliasson 1000* (S s.n.); Mar 1972, *Michelle and Ole Hamann 613* (C 24/2007/25); Dec 1974, *H.H. van der Werff 1722* (K H2007/01159/18); Feb 1939, *T.W.J. Taylor, G21* (K H2007/01159/10). **Santiago Island:** Jan 1906, *Alban Stewart 3154* (GH 233544); Jan 1906, *Alban Stewart 3157* (CAS 27255); Jan 1967, *Inga Eliasson 1128* (S s.n.); Aug 1972, *Michelle and Ole Hamann 2053* (C 24/2007/23); Aug 2005, *Conley K. McMullen 870* (JMUH 13770). **Unknown Island:** no date, *Andersson 123* (C 24/2007/14, K 449160).

Nomenclatural history.—Andersson first described this species in 1855 as *Varronia canescens* Anderss. In 1891, Kuntze moved both *Varronia* P. Br. and *Cordia* L. into *Lithocardium* Kuntze. However, the epithet "*canescens*" was occupied by *Cordia canescens* Kunth which had priority, so Kuntze (1891) renamed *V. canescens* Anderss. as *Lithocardium anderssonii* Kuntze. Subsequently, Gürke (1893) later reclassified *L. anderssonii* Kuntze as *Cordia*. More recently Borhidi (1988) moved *C. anderssonii* (Kuntze) Gürke back into *Varronia* as *V. anderssonii* (Kuntze) Borhidi without regard to Andersson's (1855) original nomenclature for the species. Therefore, Borhidi's change is invalid (see Art. 45.3 and Art. 53.1, McNeill et al. 2006). As such, *V. canescens* Andersson should be considered the correct name for this species based upon Miller and Gottschling's (2007) reinstitution of genus *Varronia*.

Contribution of this study.—Based on characters observed on the type specimen, this species has lanceolate leaves with finely serrate to crenate margins (Fig. 11), but these characters were variable when observing all herbarium specimens. *Varronia canescens* has a propensity to look most similar to *V. scouleri*, though the leaves of *V. canescens* do not tend to be as long as those found on *V. scouleri*, nor are the leaf margins on *V. canescens* as coarsely serrate as those generally found on *V. scouleri*. The pubescence on the adaxial surface of the leaves of *V. canescens*, when present, is typically appressed (Fig. 12) or weakly erect (Fig. 13) and composed mostly of stellate and forked, occasionally simple hairs. The abaxial leaf surfaces are densely pubescent, with

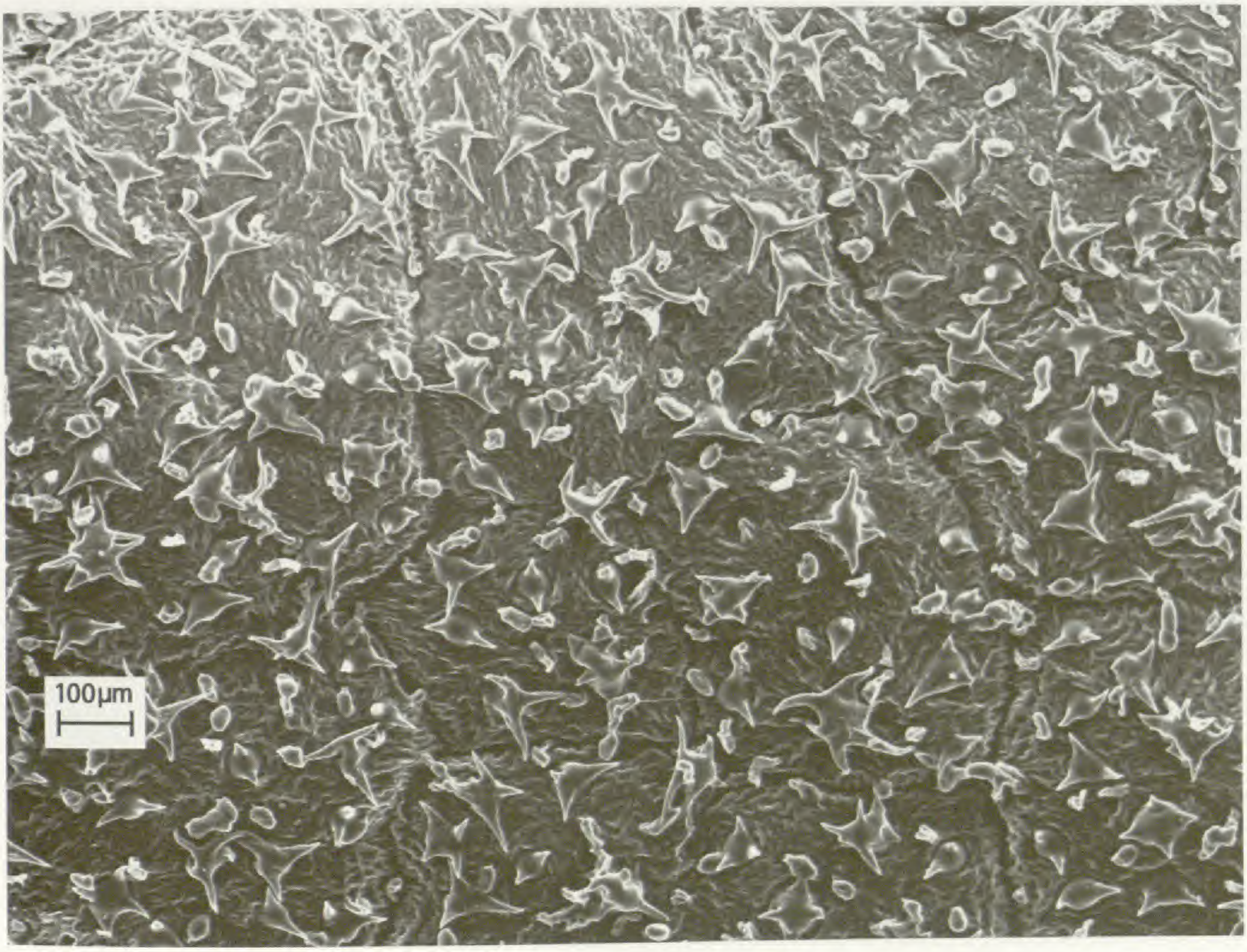

Fig. 12. *Varronia canescens* **adaxial leaf surface displaying appressed stellate and forked hairs. Scale represents 100 µm. Specimen: Jul 2005,** ***Conley K. McMullen, 824*** **(JMUH 13675).**

appressed stellate, forked, and simple hairs (Fig. 14). The abaxial pubescence of *V. canescens* is the densest of any of the four endemic species and the most obviously appressed. In addition, the hairs on the veins do not tend to be any larger than those found in the margins, providing another character that distinguishes *V. canescens* from the other three endemic species. The pubescence on the calyx is composed of appressed stellate, forked, and simple hairs, which are a uniform length through the length of the calyx. In contrast to the other species, the hairs are generally very short. The calyx lobes are as long as or shorter than the calyx tube at anthesis.

4. Varronia scouleri (Hook. f.) Andersson, Kongl. Vetensk.-Akad. Handl. 1853:204. 1855. ≡ *Cordia scouleri* Hook. f., Trans. Linn. Soc. London 20:200. 1847. Type (Porter 1980): ECUADOR. Galápagos Islands. James Island (Santiago Island): no date, *John Scouler s.n.* (holotype: K 449165!). ≡ *Lithocardium scouleri* (Hook. f.) Kuntze, Revis. Gen. Pl. 2:977. 1891. ≡ *Varronia scouleri* (Hook. f.) Borhidi. Acta Bot. Hung. 34:387. 1988, nom. illeg.

Species description.—Varronia scouleri is an ascending branched shrub, with dullish dark gray bark with circular or transversely lenticular lenticels (Wiggins & Porter 1971). Young twigs sparsely pubescent with generally appressed stellate and forked, or sometimes simple hairs. Some noticeably larger, more robust hairs may also be observed. Leaves lanceolate, 2.3–17.5 cm long, 0.5–5.0 cm wide, with coarsely serrate margins; adaxial leaf surfaces dark green and pubescent with erect simple, forked, and sometimes stellate hairs (Fig. 1d); abaxial leaf surfaces lighter green and sparsely pubescent with weakly appressed stellate and forked, sometimes simple hairs which are noticeably more robust on elevated veins (Fig. 2d). Inflorescence globose-capitate, on peduncles 3.0–5.0 mm long (Wiggins & Porter 1971). Calyx globose in bud, campanulate after anthesis, 5-lobed; lobes are 4.0 mm long, excluding elongated slender lobe tips, and 3.0–4.0 mm wide (Wiggins & Porter 1971);

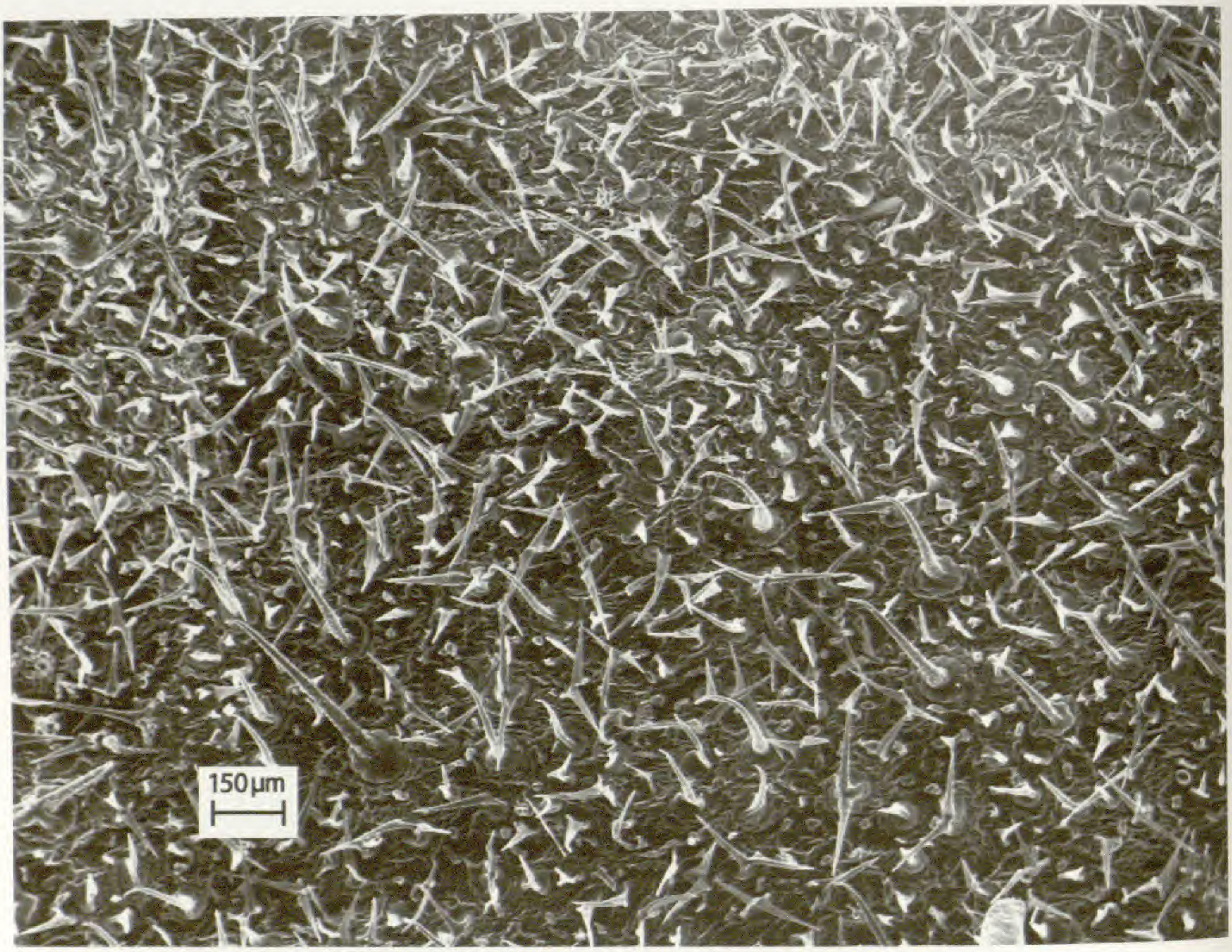

Fig. 13. ***Varronia canescens*** **adaxial leaf surface displaying weakly erect stellate, forked, and simple hairs. Scale represents 150 µm. Specimen: Mar 2007,** ***Conley K. McMullen and Michael Shane Woolf, 884*** **(JMUH 13804).**

elongated lobe tips may be as long as, or longer than the lobe, 4.0–8.0 med mer; calyx lobes usually longer than calyx tube at anthesis (Fig. 3d). Pubescence on the calyx composed of erect and simple, sometimes forked or stellate hairs. Simple hairs noticeably longer on the calyx lobes than on the calyx tube (Fig. 3d). Corolla white, 5-lobed, tubular-funnelform, with a tube 6.0–8.0 mm long; lobes short, crispate (Wiggins & Porter 1971). See Wiggins and Porter (1971) for a more thorough description of the reproductive parts and fruits of this species.

Distribution and habitat.—Endemic to the Galápagos Islands. This species is found among lava boulders and in rocky soil among other shrubs. It is also sometimes found as an understory shrub in forested areas. *Varronia scouleri* is found from near sea level to 400 m. *Varronia scouleri* on Santa Cruz Island near the Charles Darwin Research Station and town of Puerto Ayora are known to be found among *Bursera graveolens*, *Opuntia echios* var. *gigantea*, *Jasminocereus thouarsii* var. *delicatus*, *Parkinsonia aculeata*, *Croton scouleri* var. *scouleri*, *Waltheria ovata*, *Castela galapageia*, *Cordia lutea*, *Clerodendrum molle*, *Scutia spicata* var. *pauciflora*, *Passiflora foetida*, and *Acacia rorudiana*. Specimens have been collected only from Floreana, Santa Cruz, and Santiago Islands (Fig. 4). This species has the most limited distribution of the endemic Galápagos *Varronia* species.

Specimens examined. **ECUADOR. GALÁPAGOS ISLANDS. Floreana Island:** Dec 1966, *Inga Eliasson 836* (S s.n.); Feb 1928, *Borghild Rorud 33* (S s.n.). **Santa Cruz Island:** Mar 2007, *Conley K. McMullen and Michael Shane Woolf 876* (JMUH 13787); Mar 2007, *Conley K. McMullen and Michael Shane Woolf 875* (JMUH 13784); Mar 2007, *Conley K. McMullen and Michael Shane Woolf 874* (JMUH 13782); Mar 2007, *Conley K. McMullen and Michael Shane Woolf 873* (JMUH 13782); Mar 2007, *Conley K. McMullen and Michael Shane Woolf 872* (JMUH 13775); Jul 2005, *Conley K. McMullen 836* (JMUH 13701); Jul 2005, *Conley K. McMullen 835* (JMUH 13697); Jul 2005, *Conley K. McMullen 832* (JMUH 13692); Jul 2005, *Conley K. McMullen 833* (JMUH 13693); Jul 2005, *Conley K. McMullen 834* (13695); Apr 1930, *H.K. Svenson 7* (GH 233525); Feb 1967, *Ira L. Wiggins and Duncan M. Porter 610* (CAS 528171, GH 244001); Feb 1964, *Ira L. Wiggins 18472* (GH 244000); May 1932, *John*

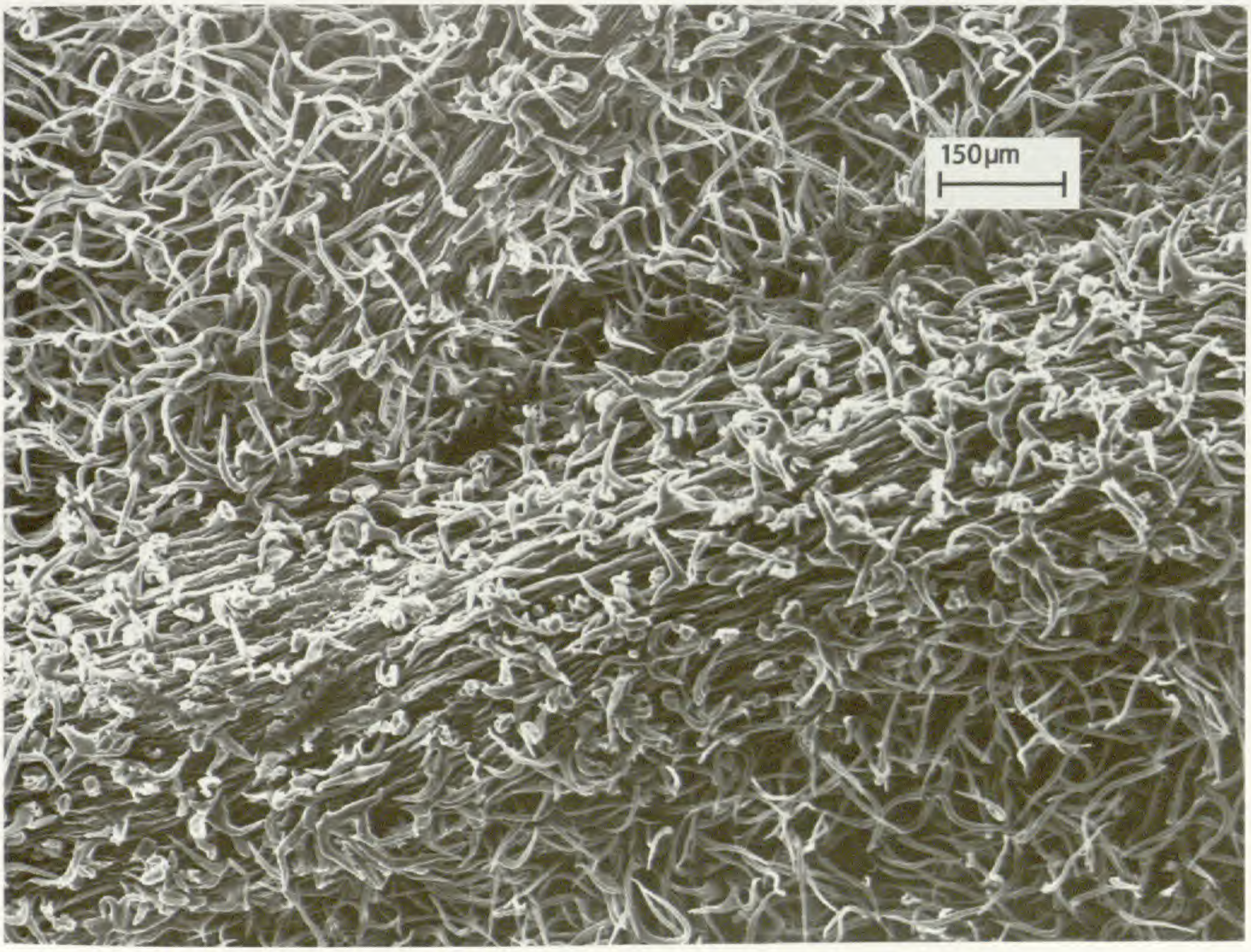

Fig. 14. *Varronia canescens* abaxial leaf surface displaying densely pubescent stellate, simple and forked hairs. Hairs on veins are generally the same size as found in margins. Scale represents 150 µm. Specimen: Jul 2005, *Conley K. McMullen, 824* (JMUH 13675).

Thomas Howell 9075 (CAS 468104, GH 233550, NY s.n.); Jan 1964, *Syuzo Itow 1* (CAS 579305); Mar 1970, *Syuzo Itow 30800-3* (CAS 623522); May 1970, *Syuzo Itow 52200-1* (CAS 623519); Feb 1964, *Ira L. Wiggins 18472* (CAS 619424); Jun 1970, *Syuzo Itow 62600-1* (CAS 623520); Feb 1964, *Luis A. Fournier 157* (CAS 705256); Feb 1967, *Ira L. Wiggins and Duncan M. Porter 710* (CAS 528135); Feb 1964, *Syuzo Itow 45* (CAS 579313); Jun 1932, *H.J.F. Schimpff 40* (NY s.n.); 1939, *T.W.J. Taylor s.n.* (NY s.n.); Jun 1932, *H.J.F. Schimpff 40* (BKL 81350, S s.n.); May 1959, *Gunnar Harling 5194* (S s.n.); Dec 1966, *Inga Eliasson 986* (S s.n.); Jan 1967, *Inga Eliasson 1192* (S s.n.); De 1966, *Inga Eliasson 985* (S s.n.); Dec 1966, *Inga Eliasson 990* (S s.n.); Dec 1966, *Inga Eliasson 992* (S s.n.); Dec 1966, *Inga Eliasson 984* (S s.n.); Jan 1967, *Inga Eliasson 1200* (S s.n.); Nov 1966, *Inga Eliasson 515* (S s.n.); Nov 1966, *Inga Eliasson 513* (S s.n.); Jun 1972, *Michelle and Ole Hamann 1598* (C 24/2007/11); Jan 1972, *Michelle and Ole Hamann 155* (C 24/2007/9); Jan 1972, *Michelle and Ole Hamann 154* (C 24/2007/8); Mar 1981, *O. Seberg 1747* (C 24/2007/7); Apr 1972, *Michelle and Ole Hamann 1177* (C 24/2007/4); Mar 1972, *Michelle and Ole Hamann 726* (C 24/2007/2); Apr 1983, *Phyllis S. Bentley 318* (K H2007/01159/12); Apr 1930, *H.K. Svenson 7* (K H2007/01159/11). **Santiago Island:** Aug 2005, *Conley K. McMullen 864* (JMUH 13758); Aug 2005, *Conley K. McMullen 865* (JMUH 13761); Aug 2005, *Conley K. McMullen 866* (JMUH 13763); Aug 2005, *Conley K. McMullen 867* (JMUH 13764); Aug 2005, *Conley K. McMullen 868* (JMUH 13766); Aug 2005, *Conley K. McMullen 869* (JMUH 137869); Mar 2007, *Conley K. McMullen and Michael Shane Woolf 887* (JMUH 13811); Mar 2007, *Conley K. McMullen and Michael Shane Woolf 888* (JMUH 13813); Mar 2007, *Conley K. McMullen and Michael Shane Woolf 889* (JMUH 13815); Mar 2007, *Conley K. McMullen and Michael Shane Woolf 890* (JMUH 13817); Aug 1891, *G. Baur 209* (GH 233524); Aug 1972, *Michelle and Ole Hamann 2140* (C 24/2007/3); 1825, *John Scouler s.n.* (K 449165).

Nomenclatural history.—Hooker first described this species in 1847 as *Cordia scouleri* Hook. f., transferred by Andersson (1855) into *Varronia,* and later *Lithocardium* by Kuntze (1891). Borhidi (1988) renamed the species *Varronia scouleri* (Hook. f.) Borhidi, without regard to Andersson's (1853) designation rendering this combination illegitimate (see Art. 45.3 and Art. 53.1, McNeill et al. 2006). The currently accepted name for this species is *Varronia scouleri* Anderss., based upon Miller and Gottschling's (2007) reinstitution of genus *Varronia.*

Contribution of this study.—Based on characters observed in the type specimen, this species typically has

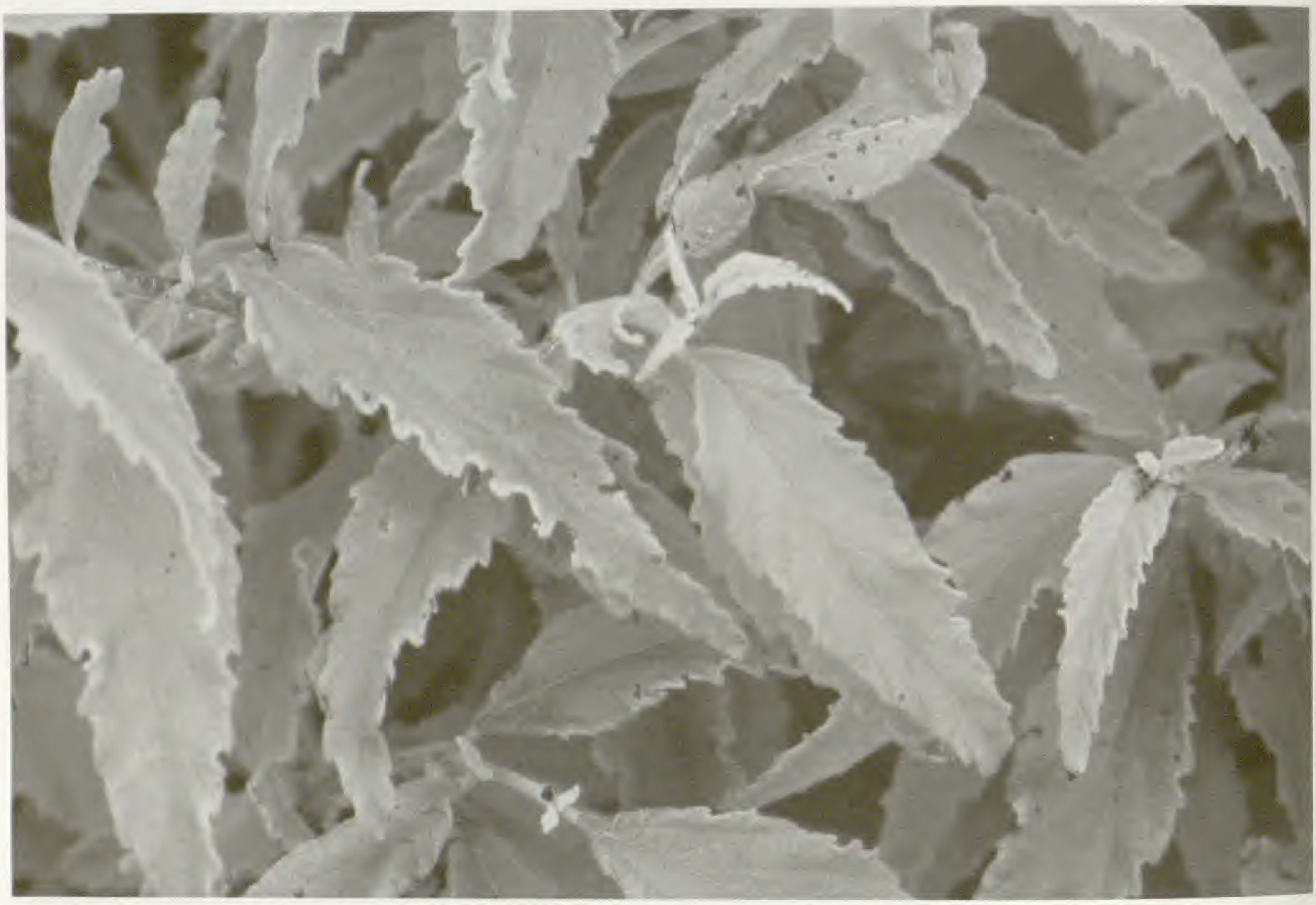

Fig. 15. View of typical *Varronia scouleri* lanceolate leaves with serrate margins. Photograph courtesy of Conley K. McMullen. Specimen: Mar 2007, *Conley K. McMullen and Michael Shane Woolf, 889* (JMUH 13815).

lanceolate leaves with coarsely serrate margins (Fig. 15), but this was variable when observing other herbarium specimens. As previously mentioned, *V. scouleri* tends to have longer leaves and more coarsely serrate margins than *V. canescens*, the most similar species. The adaxial leaf surface of *V. scouleri* is pubescent with erect and simple or forked (Fig. 16) or sometimes stellate (Fig. 17) hairs. Abaxial leaf surfaces are sparsely pubescent with appressed stellate and forked, sometimes simple, hairs (Fig. 18). Much longer and more noticeably robust hairs can be found on the veins. These large hairs on the veins are very distinctive of this species. Pubescence of the calyx is composed of erect and simple, and sometimes forked or stellate hairs. Simple hairs on the calyx lobes are noticeably longer than the hairs on the calyx tube. The calyx lobes themselves are usually longer than the calyx tube at anthesis. *Varronia scouleri* is distinct in that its calyx lobes can be exceptionally long and outwardly splayed compared to the other three species.

DISCUSSION

All four species of *Varronia* endemic to the Galápagos Islands deserve recognition as distinct species. Based upon this morphological study, each species can be distinguished by a combination of characters. In addition, these characters appear to have remained constant over the 185 years these species have been collected. While this is not a substantially long period of time in terms of evolution, it does indicate that the characters used in this study remain relatively stable during the time period in which these specimens were collected and studied. No obvious hybrids (plants with characteristics of more than one species) were observed during the morphological study, suggesting that there may be little if any hybridization between species. Based on personal observations, the individual species of *Varronia* do not generally appear to be found within close proximity to one another, further reducing the possibility of hybridization through shared pollinators. Additionally, these *Varronia* species are distylous, and initial research on *V. scouleri* indicates that almost all fruit set is the result of pin

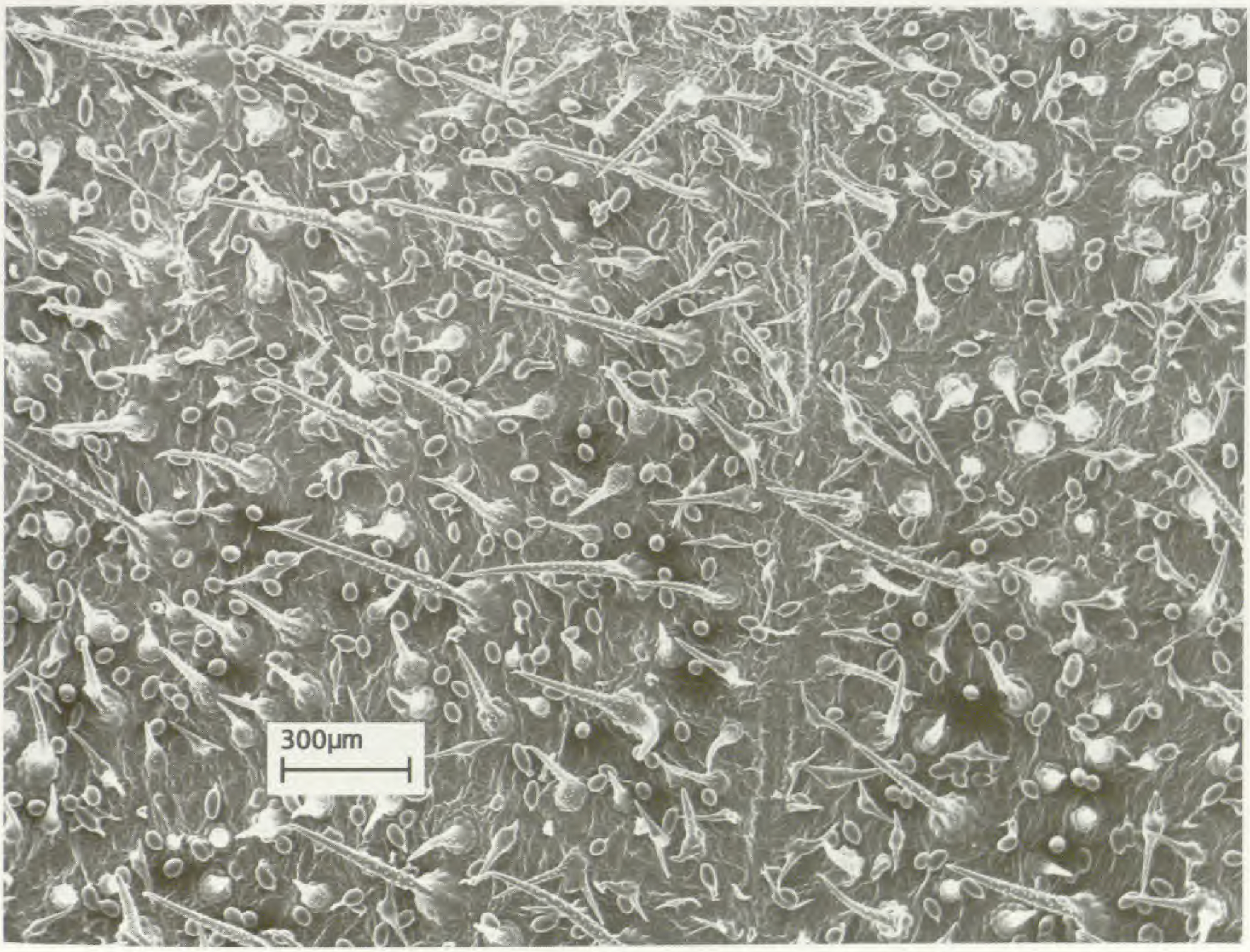

Fig. 16. *Varronia scouleri* adaxial leaf surface displaying erect simple and forked hairs. Scale represents 300 µm. Specimen: Mar 2007, Conley K. McMullen and Michael Shane Woolf, 876 (JMUH 13787).

flowers that have been pollinated with pollen from thrum plants of the same species (CKM and JKS, unpublished data). Thrum plants produce few, if any, fruits, indicating that only about 50% of a local plant population is capable of producing fruit. This initial research also indicates that only about 14% of flowers produce fruits. The limited ability of *Varronia* to effectively produce fruit further limits the possibility of established mature hybrid individuals. Future research on these species will include controlled pollination crosses between species to determination if hybridization is possible, and if so, the viability of the resulting hybrid individuals.

Due to the limited fruiting ability of these species, future recruitment may be cause for concern if the habitat of these species is disturbed. In 1959, the Ecuadorian government created the Galápagos National Park, which comprises about 97% of the total landmass of the archipelago (Camancho 2005). Because such a significant portion of the Islands are part of the National Park, the vast majority of *Varronia* populations are also likely to be in these protected areas. This existing protection decreases the risk of habitat destruction that could potentially reduce the survival of these species. Based on February 2011 observations on Santa Cruz Island near the Charles Darwin Research Station and the town of Puerto Ayora, few seedlings are visible among established populations, though mature adult plants appear to be relatively common and vigorous.

At this time, little is known about the abundance or complete distribution of *Varronia* in the Galápagos, and future field studies of these species would benefit from assessments of these populations. Data from herbarium collection labels has provided enough information to determine on which islands each species can be found (Fig. 4), but specific collection locations were rarely, or only partially provided, apart from those specimens collected by CKM. Based on current information, it is evident that each species retains its foliar morphol-

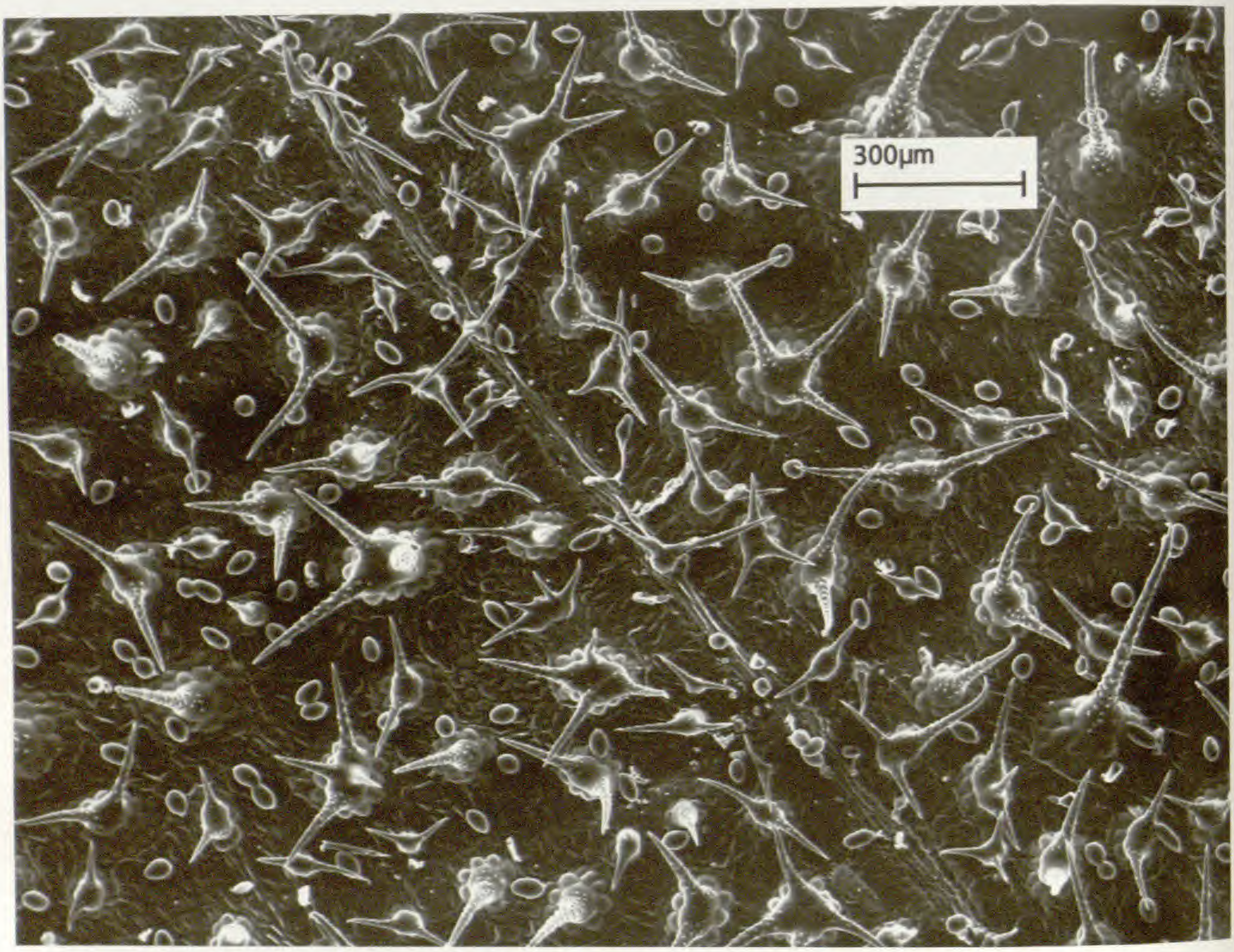

Fig. 17. ***Varronia scouleri*** **adaxial leaf surface displaying erect simple, forked, and stellate hairs. Scale represents 300 µm. Specimen: Mar 2007,** ***Conley K. McMullen and Michael Shane Woolf, 873*** **(JMUH 13782).**

ogy and can be identified across multiple islands suggesting that the characters are not geographically determined. Several islands have all four species of *Varronia* present (Fig. 4). It is possible that this is the result of collection intensity, and future studies may find that the least distributed species may in fact be present on other islands that have not previously undergone intensive collecting. Detailed GPS coordinates for *Varronia* populations in the Islands would provide the information needed to construct more complete distribution maps for each species. These species do not currently appear to be under any increased threat, and their conservation needs are unlikely to change in the near future; however, the IUCN would benefit from updated information and distributions of these species in order to reevaluate, or evaluate for the first time, the status of each species.

This study supports the existence of four morphologically distinct endemic *Varronia* species in the Galápagos Islands. While Weeks et al. (2010), did not find *V. leucophlyctis*, *V. canescens*, and *V. scouleri* to be genetically distinct from one another, this may have been due to the ITS regions that were used in the study. These regions may not be variable if these species have diverged relatively recently. Weeks et al. (2010) suggest that fingerprinting techniques that record nucleotide polymorphisms, such as microsatellites or amplified fragment length polymorphisms, would be a better method for use in the future. Future molecular studies may find that genetic variation exists in now-unexamined regions, but until that time, these populations deserve recognition as morphologically different species based on this study.

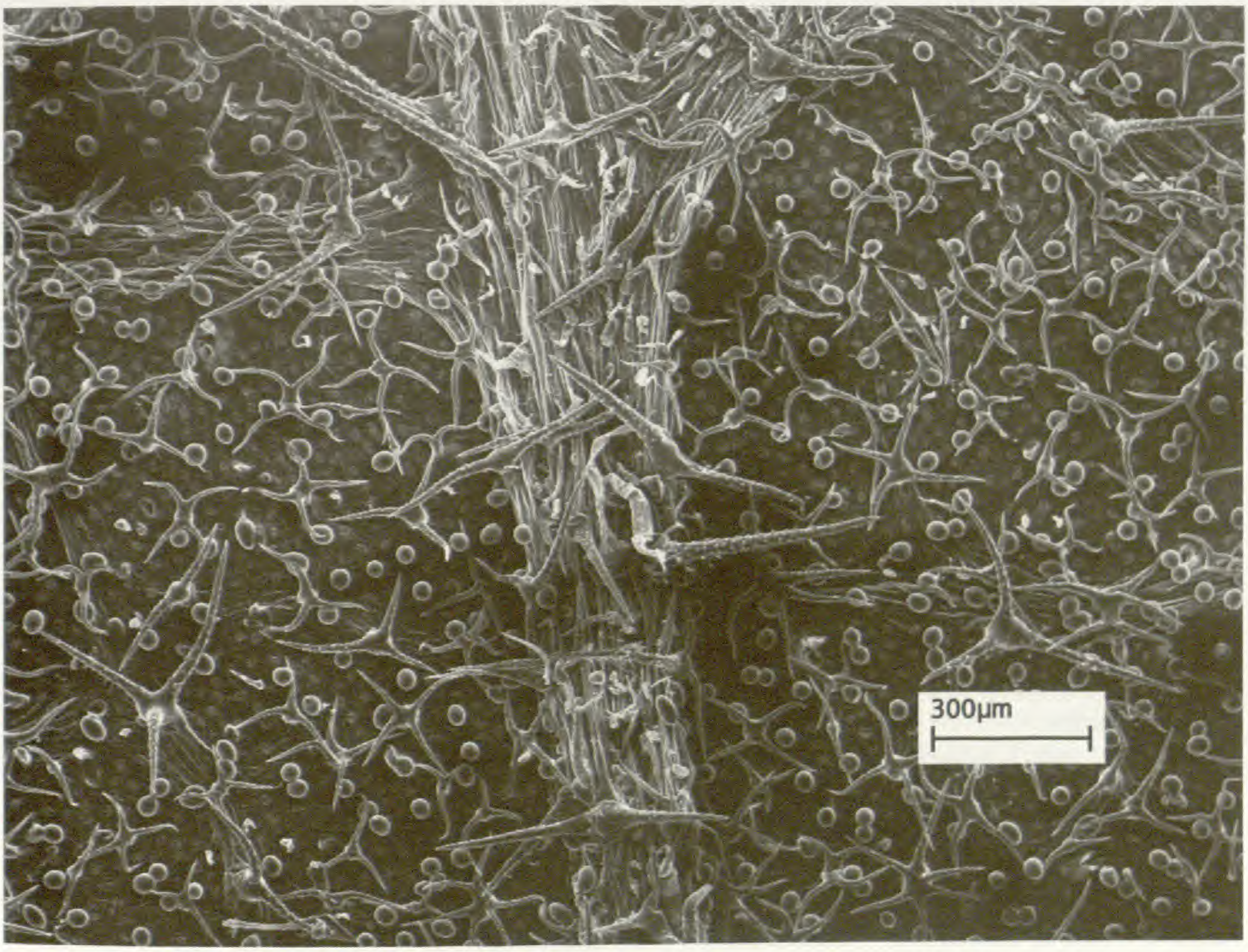

Fig. 18. *Varronia scouleri* abaxial leaf surface displaying robust simple, forked and stellate hairs on veins, and smaller, appressed stellate hairs in margins. Scale represents 300 µm. Specimen: Mar 2007, *Conley K. McMullen and Michael Shane Woolf, 873* (JMUH 13782).

CONCLUSIONS

Morphological characterization indicates the existence of four endemic species of *Varronia* in the Galápagos Islands that are distinct. The results from this study will be helpful in evaluating these species for their conservation statuses. Over 100 misidentified specimens are now correctly identified through the course of this study, and the diagnostic information provided here in the new taxonomic keys will help provide the information necessary for other specimens to be reevaluated, or new collections to be correctly identified. In addition, an effort must be made to assess the size and stability of the populations of each endemic *Varronia* species in order to evaluate how these species should be managed. Protecting the endemic species of the Galápagos is important both for the survival of the individual species as well as the continuation of the Galápagos Islands as a unique example of island evolution and diversity. Effective conservation programs to protect this exceptional diversity can only result from research that strives to document the flora and fauna of these islands. Accurate descriptions of the distinctive species of the Galápagos, such as those accomplished in this study, are the first step towards protecting and ensuring their future on the islands.

ACKNOWLEDGMENTS

JKS and CKM thank the Charles Darwin Foundation, the Charles Darwin Research Station, and the Galápagos National Park Service for logistical support during fieldwork in the Galápagos Islands. CKM thanks Lenin Cruz, Michael S. Woolf and Beattie G. Sturgill for field assistance. Thanks are extended to Michael H. Renfroe and Heather Peckham Griscom for reviewing an earlier version of the manuscript and providing constructive suggestions. James L. Reveal is gratefully acknowledged for nomenclatural advice. A special thanks also to Lance Kearns for his help in obtaining the SEM images used in this paper that provide an excellent example of many of the characters used in the new taxonomic key. Many thanks to Susana Chamorro for translation assistance, and JKS would also like to thank Reuben and Catarina Heleno for graciously providing lodging in their home in Galápagos during her field work for this study. Marc Gottschling and an anonymous reviewer provided helpful suggestions.

The following funding sources have allowed travel to the Galápagos Islands and the completion of this research: The Earl Core Student Award (Southern Appalachian Botanical Society), the Norlyn L. Bodkin Scholarship for Arboretum and Botanical Field Studies (James Madison University), the Peter T. Nielsen Annual Award for Botanical Studies (James Madison University), and the James Madison University Department of Biology. Appreciation is extended to the following herbaria for use of their *Varronia* specimens: BKL, C, CAS, CGE, GH, JMUH, K, NY, and S.

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BOOK REVIEW

Sylvan T. Runkel and Dean M. Roosa. 2010. **Wildflowers of the Tallgrass Prairie: The Upper Midwest.** (ISBN: 978-1-58729-796-0, pbk.). University of Iowa Press, 119 West Park Road, 100 Kuhl House, Iowa City, Iowa 52242, U.S.A. (**Orders:** www.uiowapress.org, 319-335-2000). $29.95, 308 pp., 131 color photos, 5.5" × 8.5".

Growing up in America, it is hard not to be exposed to the wonderful tales of Laura Ingles Wilder and her family's efforts to survive the blessings and hardships of life on the prairie. As a girl, I envisioned myself as Laura, romping through the tallgrass prairie with my pup at my side, experiencing the many adventures from eking out a living from the hard black earth, to harsh winters, to encounters with Native Americans, to one-room schoolhouses, and to lying by a stream watching the butterflies flit back and forth.

Having recently moved from Southern Wisconsin, the land of the Tallgrass Prairie, to Northern Texas' Blackland Prairie, it was meant to be that I review this wonderful guidebook, "Wildflowers of the Tallgrass Prairie, The Upper Midwest" by Sylvan T. Runkel and Dean M. Roosa. The prairie is in my blood. I would even go so far as to describe myself as a "prairie rambler" as the authors are described in the book's forward, although in no way can I claim the expertise of these two esteemed prairie experts.

Once covering approximately 221,436 square miles from Canada to Texas, tallgrass prairie was subject to the natural conditions of grazing buffalo, harsh winters, and prairie fires. Humans, however, have interfered with its natural cycles. With the invention of the steel plow, the rich and tough prairie lands soon became farmland. Today, the tallgrass prairie is estimated to cover only 1% of its original expanse. Remnants of the tallgrass prairie remain dispersed among the Upper Midwest states. In Wisconsin alone, only about 4,000 acres of tallgrass prairie remain.

Runkel and Roosa offer us a wonderful guidebook with stunning full page, color photographs by botanist Thomas Rosburg, that make one's heart long for the tallgrass prairie. The book is organized by season beginning with the early blooming pasque flower, followed with summer beauties such as Maximilian sunflower and prairie coreopsis, and ending with the lovely fall blazing star and closed gentian. Prairie grasses such as big bluestem, Indian grass, and switchgrass, among others, are an integral part of the book. The authors provide readers with both common and Latin names, as well as definitions which help the amateur wildflower enthusiast remember them. They provide detailed plant and habitat descriptions as well as historical and medicinal uses of the plant by Native Americans and pioneers.

While primarily a guidebook, the authors make an important link to the need for conservation of these vital and yet sensitive prairie lands. As they say, "If the prairie goes, an entire community is lost forever—a community that was the foundation of our Midwestern society." Find yourself a copy of this book, a pair of boots, and go ramble on the prairie. You too will be convinced of its beauty, and the need to protect it.

—*Gwen Michele Thomas, Texas Master Naturalist & Volunteer,*
Botanical Research Institute of Texas, 1700 University Dr., Fort Worth, Texas 76107-3400, U.S.A.

BOOKS RECEIVED/REVIEWS FORTHCOMING

Patricia Folley. 2011. **The Guide to Oklahoma Wildflowers.** (ISBN: 978-1-60938-046-5, pbk.). University of Iowa Press, 119 W. Park Road, 100 Kuhl House, Iowa City, IA 52242-1000, U.S.A. (**Orders:** http://www.uiowapress.org/books/2011-fall/guide-oklahoma-wildflowers.htm, Phone: 319-335-2000, Fax: 319-335-2055, Phone orders: 800-621-2736, Fax orders: 800-621-8476, E-mail: uipress@uiowa.edu). $39.95, 312 pp., 415 color photos, 1 color map, 6" × 9".

Craig Pittman. 2012. **The Scent of Scandal: Greed, Betrayal, and the World's Most Beautiful Orchid.** (ISBN: 978-0-8130-3974-9, hbk.). University Press of Florida, 15 Northwest 15th St., Gainesville, Florida 32611-2079, U.S.A. (**Orders:** http://www.upf.com). $24.95, 299 pp., b&w photos, 6" × 9".

A NEW SPECIES OF *TAPEINOSTEMON* (GENTIANACEAE) FROM THE CHOCÓ OF NORTHERN ECUADOR

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ABSTRACT

The core range of the neotropical genus *Tapeinostemon* (Gentianaceae) in the Guayana Highlands comprises six species endemic to tepui formations, while two further species occur in the Andes. *Tapeinostemon zamoranum* Steyerm. ranges from southern Colombia through Ecuador and Peru to Bolivia on Amazon-facing slopes, while **T. adulans** J.R. Grant, sp. nov. occurs on Pacific-facing slopes of the Chocó region in northern Ecuador. Inflorescence architecture and seed anatomy indicate that the new species is more closely related to *T. spenneroides* Benth. of the Guayana Highlands than to the geographically proximate *T. zamoranum*.

KEY WORDS: *Tapeinostemon*, Gentianaceae, Ecuador

RESUMEN

El núcleo de distribución del género neotropical *Tapeinostemon* (Gentianaceae) en las Guayana Highlands comprende seis especies endémicas de las formaciones tepui, mientras que las otras dos especies están en los Andes. *Tapeinostemon zamoranum* Steyerm. se distribuye desde el sur de Colombia por Ecuador y Perú hasta Bolivia en las laderas orientadas hacia el Amazonas, mientras que **T. adulans** J.R. Grant, sp. nov. está en las laderas orientadas al Pacífico de la región del Chocó en el norte de Ecuador. La estructura de de la Inflorescencia y la anatomía de la semilla Indican que la nueva especie está más relacionada con *T. spenneroides* Benth. de las Guayana Highlands que con la más cercana geográficamente *T. zamoranum*.

While examining specimens of neotropical Gentianaceae at the Missouri Botanical Garden for work largely on *Macrocarpaea* (Grant 2011; Grant & Trunz 2011), a distinctive specimen came to light. With John Pruski and Ron Liesner we determined that this was a member of the small genus *Tapeinostemon*. Species of this genus range from annual to perennial herbs that are woody at the base. The pentamerous flowers are positioned in lax axillary to terminal cymes, and depending on species are distinctly nodding or not (Struwe et al. 1999; Struwe et al. 2002). The seeds are minute with a reticulate testa with numerous important characters for species differentiation.

Tapeinostemon occurs primarily on tepui formations of the Guayana Highlands with six species: *T. breweri* Steyerm. & Maguire, *T. jauaensis* Steyerm. & Maguire, *T. longiflorum* Maguire & Steyerm., *T. rugosum* Maguire & Steyerm., *T. sessiliflorum* (Humb. & Bonpl. ex Schult.) Pruski & S.F. Sm. and *T. spenneroides* Benth. (Struwe et al. 1999). Two species occur in the Andes: the first *Tapeinostemon zamoranum* Steyerm., which has the broadest distribution of any species in the genus, ranges across several biogeographic zones from southern Colombia to the Amotape-Huancabamba region of southern Ecuador and northern Peru, to the Cordillera Central of Peru and northern Bolivia, always on Amazon-facing slopes; the second is a new species, *T. adulans* J.R. Grant described here, which occurs on Pacific-facing slopes of the Chocó region northern Ecuador. The distribution of *Tapeinostemon*, a Guayana Highland-centered genus with several species also occurring in the Andes, is similar to that of *Bonyunia* (Loganiaceae), *Potalia* (Gentianaceae), and *Tachia* (Gentianaceae) (Grant 2009); yet in *Tapeinostemon* there is an absence of a widespread species in the Amazon basin as in the other three.

Tapeinostemon adulans J.R. Grant, sp. nov. (**Figs. 1, 4 E–F**). TYPE: ECUADOR. ESMERALDAS: along road from Lita to San Lorenzo, 21.4 km from Río Lita bridge near Lita, 8.6 km NW of Alto Tambo, 17.7 km E of El Dorado, 00 55'42"N, 078 33'06"W, 744 m, less than 1 m tall, flowers greenish, 14 Oct 2007, *Thomas B. Croat 99788, with Monica Carlson & Dan Levin* (HOLOTYPE: MO).

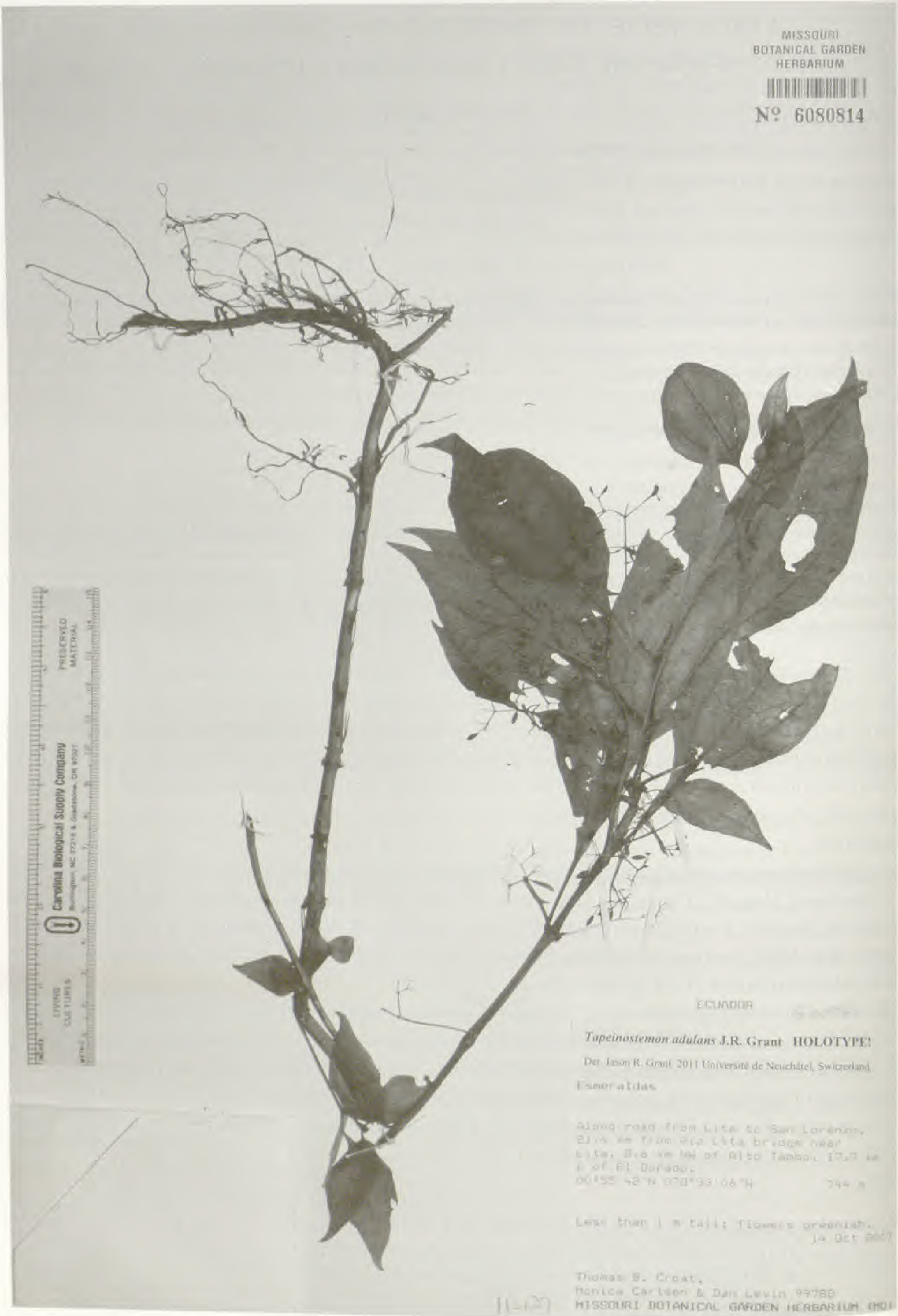
MISSOURI
BOTANICAL GARDEN
HERBARIUM
Nº 6080814
Carolina Biological Supply Company
LIVING CULTURES
PRESERVED MATERIAL
ECUADOR
Tapeinostemon adulans J.R. Grant HOLOTYPE!
Det. Jason R. Grant 2011 Université de Neuchâtel, Switzerland
Esmeraldas
Along road from Lita to San Lorenzo, 21.4 km from Rio Lita bridge near Lita, 8.6 km NW of Alto Tambo, 17.7 km E of El Dorado.
00°55'42"N 078°53'08"W 744 m
Less than 1 m tall; flowers greenish.
14 Oct 2007
Thomas B. Croat, Monica Carlsen & Dan Levin 99788
MISSOURI BOTANICAL GARDEN HERBARIUM (MO)

Fig. 1. Holotype of *Tapeinostemon adulans* J.R. Grant (*Croat 99788* [MO]). Photo Neil Villard.

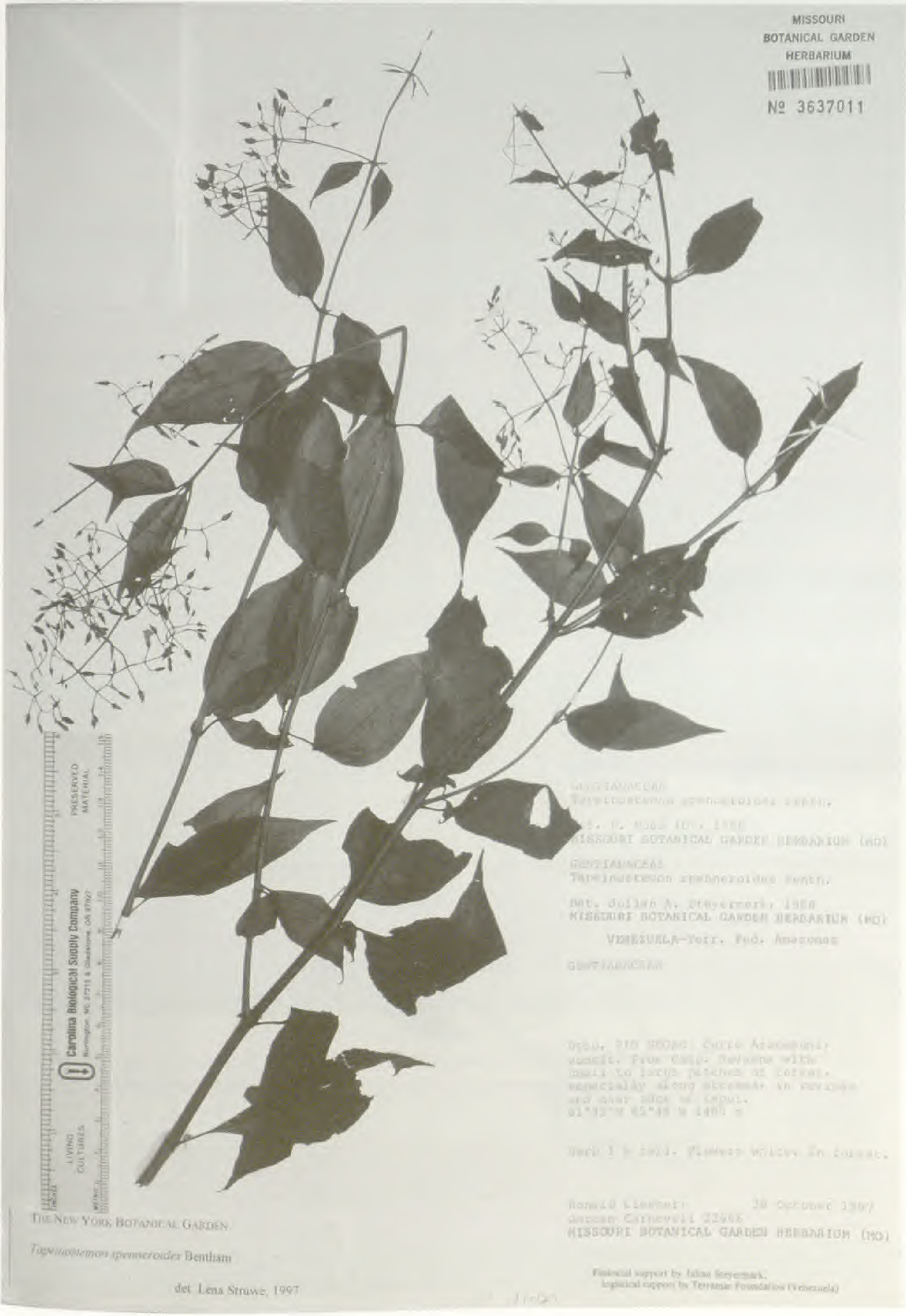
MISSOURI
BOTANICAL GARDEN
HERBARIUM
Nº 3637011
Carolina Biological Supply Company
LIVING CULTURES
PRESERVED MATERIAL
Tapeinostemon spenneroides Benth.
MISSOURI BOTANICAL GARDEN HERBARIUM (MO)
VENEZUELA-Terr. Fed. Amazonas
MISSOURI BOTANICAL GARDEN HERBARIUM (MO)
Financial support by Julian Steyermark,
logistical support by Terramar Foundation (Venezuela)
THE NEW YORK BOTANICAL GARDEN
Tapeinostemon spenneroides Bentham
det. Lena Struwe, 1997

FIG. 2. Specimen of *Tapeinostemon spenneroides* Benth. (*Liesner & Carnevali 22666* [MO]). Photo Neil Villard.

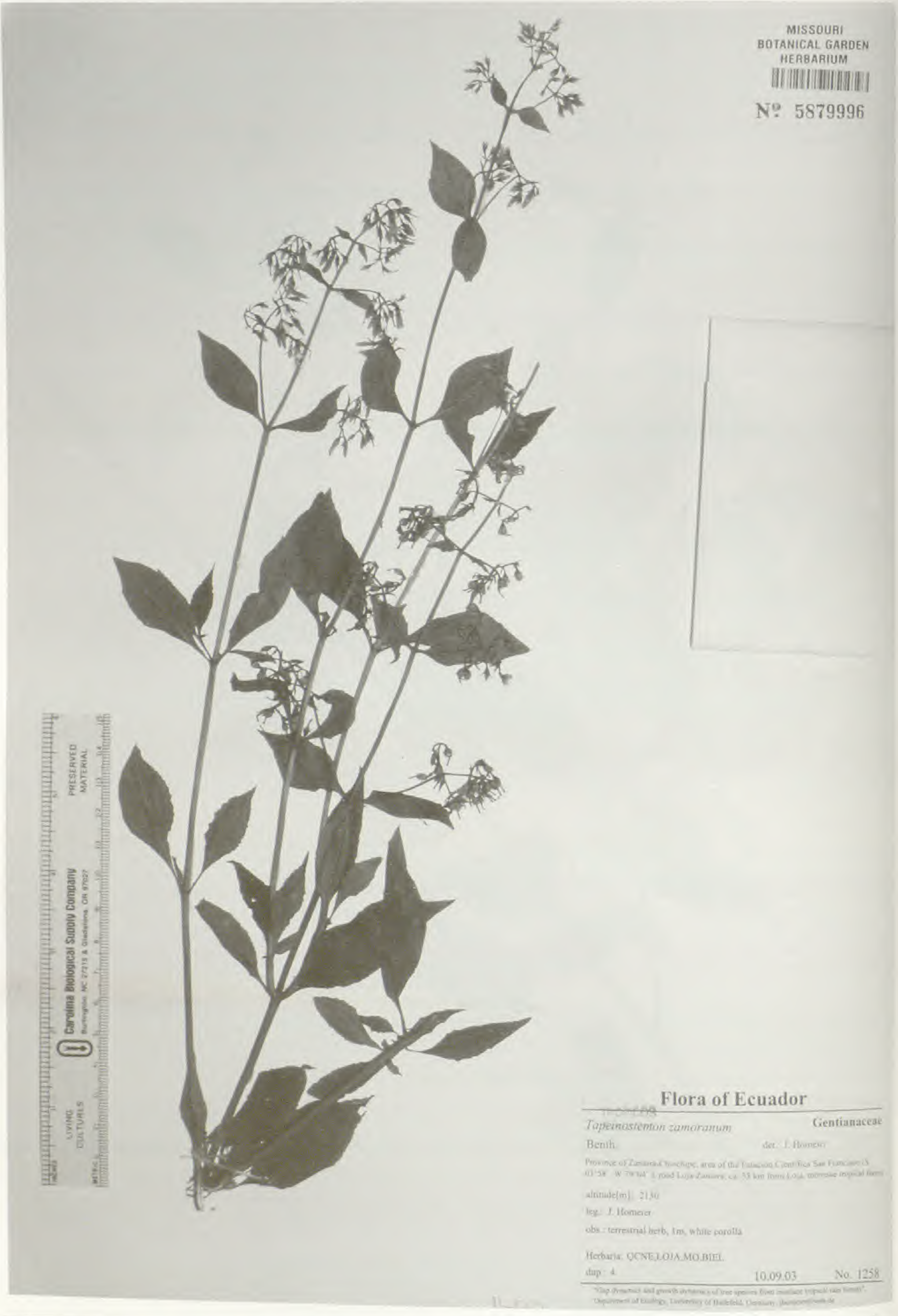
MISSOURI
BOTANICAL GARDEN
HERBARIUM
Nº 5879996
Carolina Biological Supply Company
PRESERVED
MATERIAL
LIVING
CULTURES
Flora of Ecuador
Tapeinostemon zamoranum
Gentianaceae
Benth.
altitude[m]: 2130
leg.: J. Homeier
obs.: terrestrial herb, 1m, white corolla
Herbaria: QCNE,LOJA,MO,BIEL
dup.: 4
10.09.03
No. 1258

Fig. 3. Specimen of *Tapeinostemon zamoranum* Steyerm. (*Homeier 1258* [MO]). Photo Neil Villard.

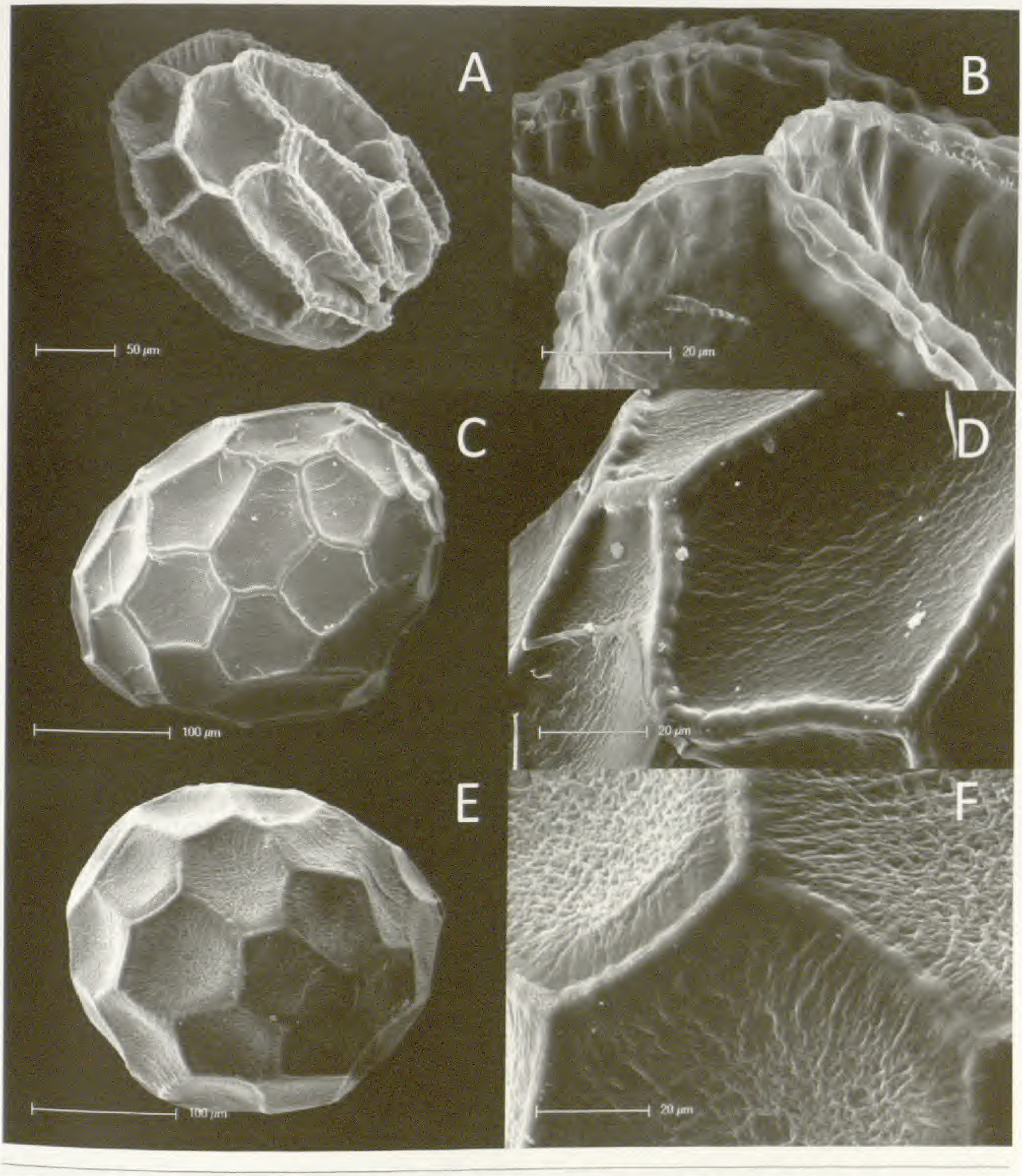

Fig. 4. Seed morphology of *Tapeinostemon*. A–B. ***T. zamoranum*** **from *Grant 4684* (NY), C–D.** ***T. adulans*** **from *Croat 99788* (MO), E–F.** ***T. spenneroides*** **from *Maguire et al. 42053* (MO). Photos M. Leboeuf.**

A *Tapeinostemon spenneroides* Steyerm. cui affinis, sed plantis brevioribus (0.5 m vs. 1–3 m), calycibus brevioribus (1.0–1.5 mm vs. 1.0–2.0 mm), corollis brevioribus (1.5–2.5 mm vs. 4–6 mm), et seminibus globosis differt.

Unbranched herb 0.5 m tall, glabrous throughout. Stems rounded below to quadrangular above. Leaves (40–) 130–140 mm long, long-petiolate; petioles (3–)20–25 mm long, blades lanceolate to ovate, (37–)110–120 × (16–)37–43 mm, entire, thin; leaf base attenuate and decurrent on the petiole; leaf apex acuminate. Inflorescences: lax axillary cymes, 30–78 mm long; branches spreading laterally, 5–20 mm long, 4–10 laxly flowered per branch. Lower bracts lanceolate to ovate, decreasing in size and becoming obovate toward the apex of the

Table 1. Seed anatomy of *Tapeinostemon.*

	T. adulans	*T. spenneroides*	*T. zamoranum*
Color	Solid reddish-brown	Solid reddish-brown	Golden translucent
Length and width	225–250 × 200–250 µm	250–300 × 200–240 µm	200–250 × 155–180 µm
Shape	Globose to ovoid, as a geodesic sphere or spherical fullerene [buckminsterfullerene or buckyball or soccer-ball shaped]	Elliptic to ovoid, as a disordered spherical fullerene	Elliptic to ovoid
Testa	Reticulate with regular polygonal cells (pentagonal and hexagonal); cells shallowly concave	Reticulate with regular to irregular polygonal cells (pentagonal and hexagonal, some lengthened with the elliptic seed shape; cells shallowly concave	Reticulate with irregular polygonal cells (square, pentagonal to hexagonal) of uneven size and length; cells deeply concave
Anticlinal walls	Straight, only slightly raised and thickened; therefore each seed appears as facetted sphere	Straight to curving, thick, raised vertically to sloping; inner walls with irregular bead-like thickenings	Straight to curving, thin, strongly raised vertically; inner walls with band-like thickenings
Cuticle	Matte; crater-like with a radiating rugose surface	Shiny; smooth to covered in faint regular striations	Shiny; smooth to traversed with band-like thickenings from the anticlinal walls

inflorescence; lower bracts petiolate, upper bracts sessile; bract petioles 0–3 mm; bracts 2–14 × 0.5–32 mm; bract base cuneate to attenuate and decurrent on bract petiole; bract apex obtuse to acuminate.. Flowers pedicellate, pedicels 1–8 mm. Sepals separate to the base, glabrous, ecarinate, narrowly triangular, 1.0–1.5 × 0.25–0.33 mm, apex acuminate to acute. Corolla funnel-shaped, 1.5–2.5 × 0.33–0.5 mm, greenish (*Croat 99788*), corolla lobes less than 0.5 mm long, corolla lobe apex acute. Androecium and gynoecium unknown (too few flowers to risk damaging the specimen). Capsules ellipsoid to obovoid, 3–5 × 1–2 mm, rugose, bilocular, each locule with around 80 seeds (ca. 160 seeds per fruit). Seed characters in Table 1.

Morphology and similarities.—*Tapeinostemon adulans* (Fig. 1) is distinct in being an unbranched 50 cm tall herb with short axillary inflorescences and globose-shaped seeds. It is similar to *T. spenneroides* (Fig. 2) in its overall form, inflorescence architecture, leaf shape, non-undulating leaf margins, and seed morphology, but differs in its short stature, smaller calyx 1.0–1.5 vs. 1.0–2.0 mm long, smaller corolla 1.5–2.5 vs. 4–6 mm, and seed characters listed below. *Tapeinostemon zamoranum* (Fig. 3) has crenate undulating leaf margins, flowers that are distinctly nodding, and an unique seed morphology. In the key to species of *Tapeinostemon* by Struwe et al. (1999), both *T. adulans* and *T. zamoranum* will key to *T. spenneroides.*

Seed morphology.—The seeds of *Tapeinostemon spenneroides* have been characterized by Bouman et al. (2002). Here, the seeds of two additional species *T. adulans* (Fig. 4 E–F) and *T. zamoranum* (Fig. 4 A–B) as well as *T. spenneroides* (Fig. 4 C–D) are described and illustrated. The calyx and corolla which are usually good characters in differentiating species, are so small in *Tapeinostemon* that they seem somewhat unreliable when dried as herbarium specimens for clear species differentiation. Therefore, seed anatomy is a useful character to distinguish these three species. The seeds of *Tapeinostemon* range in color from solid reddish brown to golden translucent and are minute (200–300 × 155–250 µm), globose, elliptic to ovoid, with a reticulate testa. The seeds of *T. adulans* and *T. spenneroides* are similar to that of two other neotropical genera, *Coutoubea* and *Schultesia*, while the seeds of *T. zamoranum* appear similar to *Cicendia* (see photos in Bouman et al. 2002). The characteristics of these three species can be seen in Table 1.

Distribution and habitat.—*Tapeinostemon adulans* occurs in the diverse Chocó region on lower elevation Pacific-facing slopes of the Andes of northern Ecuador.

Etymology.—From the Latin, *adulans*, adulatory, for the collector of the type, Thomas B. Croat of the Missouri Botanical Garden.

ACKNOWLEDGMENTS

I thank Jennifer Kuhl at the Missouri Botanical Garden for her help in finding and sending information on various specimens. I also acknowledge assistance from several other colleagues at MO during my visit there in summer 2011, especially Ron Liesner and John Pruski. Scanning electron microscope photos were prepared with Mireille Leboeuf at the CSEM (Centre Suisse d'Electronique et de Microtechnique) in Neuchâtel, Switzerland. Marion J. Jansen-Jacobs and James S. Pringle provided helpful review comments, thus improving the manuscript.

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Grant, J.R. and V. Trunz. 2011. De Macrocarpaeae Grisebach (ex Gentianaceis) speciebus novis X: a synopsis of the genus in montane Atlantic forests of Brazil. Harvard Pap. Bot. 16:399–420.

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BOOK REVIEW

CANDACE SAVAGE. PRINCIPAL PHOTOGRAPH BY JAMES R. PAGE. ILLUSTRATIONS BY JOAN A. WILLIAMS. 2011. **Prairie: A Natural History.** (ISBN: 978-1-55365-588-6, pbk.). Greystone Books, 2323 Quebec Street, Suite 201, Vancouver BC V5T 4S7, CANADA. (**Orders:** www.dmpibooks.com). $29.95, 320 pp., color throughout, b/w illustrations, 7.5" × 10".

Prairie: A Natural History provides both a historical and present-day story of the North American prairie; a story that eloquently weaves together threads of botany, geology, biology, archaeology, chemistry, ranch management, and anthropology to produce a tapestry of the prairie. Savage's writing style will transport readers to the sites of her research. "Climb up there on a blue day in early September," she writes about the Frenchman Valley in southern Saskatchewan, "out and onto the bald steppe at the top, and the wind will slam against you as if it had a grudge against anything that dared to raise its head above the grasses." Corresponding pictures, maps, and botanical illustrations provide greater detail to this piece of art—augmenting readers' understanding and appreciation for this ecological wonder. The final details that truly make this book a piece of art are the side stories that compliment the main threads of investigation, e.g., Cheyenne folk lore, excerpts from Lewis and Clark's diaries, agricultural practices, and animal behaviors.

Savage has written a literary piece that belongs both on a coffee table and in the classroom. The chapters, which focus on individual elements of the prairie (e.g., soil, water, woodlands, animals, and land management), are written so they can stand alone, yet together they provide a holistic representation of a vastly complicated system. Both prairie novices and experts will find this book illuminating due to its diversity of topics and its inclusion of both basic and intermediate levels of subject matter. From simple definitions to more complex connections, this book will find its way into the hearts of those who read it.

Prairie: A Natural History argues for the conservation of one of the most endangered ecological systems. Savage provides a historical view of how the nature of the prairie has changed due to both natural and human-made conditions, and she delicately balances the severity of the issue of the prairie's survival with hope for the future. Individuals who ask the question, "Why save the North American prairie?," will be illuminated with each turn of the page.

—*Amanda Stone Norton, Ph.D.,*
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BOOKS RECEIVED/REVIEWS FORTHCOMING

ROBERT B. SHAW. PHOTOGRAPHS BY PAUL MONTGOMERY AND ROBERT B. SHAW. 2012. **Guide to Texas Grasses.** (ISBN: 978-1-60344-186-5, pbk. flexbound). Texas A&M University Press, John H. Lindsey Building, Lewis Street, 4354 TAMU, College Station, Texas 77843-4354, U.S.A. (**Orders:** www.tamupress.com, 800-826-8911). $45, 1080 pp., line drawings, distribution maps, color throughout, 7" × 10".

FRED DORTORT. 2011. **The Timber Press Guide to Succulent Plants of World: A Comprehensive Reference to More Than 2000 Species.** (ISBN: 978-0-88192-995-9, hbk.). Timber Press, Inc., The Haseltine Building, 133 S.W. Second Avenue, Suite 450, Portland, Oregon 97204-3527, U.S.A. (**Orders:** www.timberpress.com, 800-327-5680). $49.95, 344 pp., color throughout, 8.5" × 11".

SCOTT CALHOUN. 2012. **The Gardener's Guide to Cactus: The 100 Best Paddles, Barrels, Columns, and Globes.** (ISBN: 978-1-609469-200-6, Pbk.). Timber Press, Inc., The Haseltine Building, 133 S.W. Second Avenue, Suite 450, Portland, Oregon 97204-3527, U.S.A. (**Orders:** www.timberpress.com, 800-327-5680). $24.95, 227 pp., color throughout, 8" × 9".

LECTOTYPIFICATION OF *BAUHINIA NERVOSA* (LEGUMINOSAE: CAESALPINIOIDEAE)

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ABSTRACT

A specimen at K has been designated here as the lectotype of *Bauhinia nervosa* (Benth.) Wall. ex Baker.

RESUMEN

Un espécimen depositado en K se designa aquí como lectotipo de *Bauhinia nervosa* (Benth.) Wall. ex Baker.

In the course of my taxonomic studies on the Indian Bauhinias I have sometimes faced a great difficulty in locating a particular specimen cited as type by the author(s). This paper deals with one of such problems encountered by me.

Larsen and Larsen (1984: 35) cited India '[Sylhet (type), Assam, Khasya], China (?), Upper Burma' under the distribution of *Bauhinia nervosa* (Benth.) Wall. ex Baker [basionym *Phanera nervosa* Benth.].

Zhang and Zhu (2006) cited 'Type: Bangladesh. Sylhet: Without precise locality, *Wallich* 5777 (holotype, K!)'. They have, however, neither given a clue in their publication so that one can find out the holotype examined by them at K, nor any specimen at K has been annotated by them accordingly.

In the protologue of *Phanera nervosa*, Bentham (1852: 262) cited '*Bauhinia nervosa*, WALL. *Cat*. n. 5777. In mont. Sillet' after the morphological description.

The specimen at K-WALLICH bears a piece of paper on the top left hand side on which the name *Bauhinia nervosa* Wall is inscribed and written as: Ching akahoo (?) this was found in the Katchar Hill climber yellow flower stamens reddish like style yellow this flower has good smell this was found in the month of October 1822. Pinned to it there is another strip of paper on which it is inscribed as: 5777 *Bauhinia nervosa* Mont. Sillet LD (?) in an exactly same pattern of handwriting as in Wallichian Catalogue. In another small piece of paper affixed on the top corner of the right hand side there is the name *Bauhinia nervosa* Wall, 5777, Cachar Montes 1823. This specimen is unlikely to have been studied by Bentham because neither any of the morphological characters stated on the sheet has been included in the protologue nor the place of collection has been stated to be Katchar Hill/Cachar Montes and so also the date of collection.

At K (000760781) there is a relevant herbarium sheet bearing the stamp 'HERBARIUM BENTHAMIANUM 1854'. This stamp suggests that the specimen was donated by Bentham in 1854 from his own herbarium to the Kew herbarium when he found that the maintenance of his own herbarium had become too expensive for him (http://en.wikipedia.org/wiki/George_Bentham; http://www.kew.org/heritage/people/bentham.html; http://www. anbg.gov.au/biography/bentham.george.html) [also see under Bentham's HERBARIUM and TYPES in Stafleu and Cowan, TL2 1:173. 1976]. This sheet has 3 separate leaves (all in detached condition) and an inflorescence. One of the leaves is folded, slightly damaged, and its lobe tips are not evident. The data inscribed on the sheet in pen are as follows: 1) *Bauhinia nervosa*, Sillet Mont, H.I. 5777 (seen on the left bottom of the inflorescence); 2) *Phanera nervosa* Bth, Pl. Jungh. 1. 262 (seen on the left bottom of the folded leaf); and 3) almost in the middle of the sheet, it has an inscription in pencil as follows: 5777, *B nervosa*, Sillet Mont, cad Assam Griff in [illegible] (not associated with any of the 4 specimens). One of the remaining two leaves is on the top left and the other is at the bottom left. The left top leaf lobes are distinctly acute, whereas the left bottom leaf lobes are acutish.

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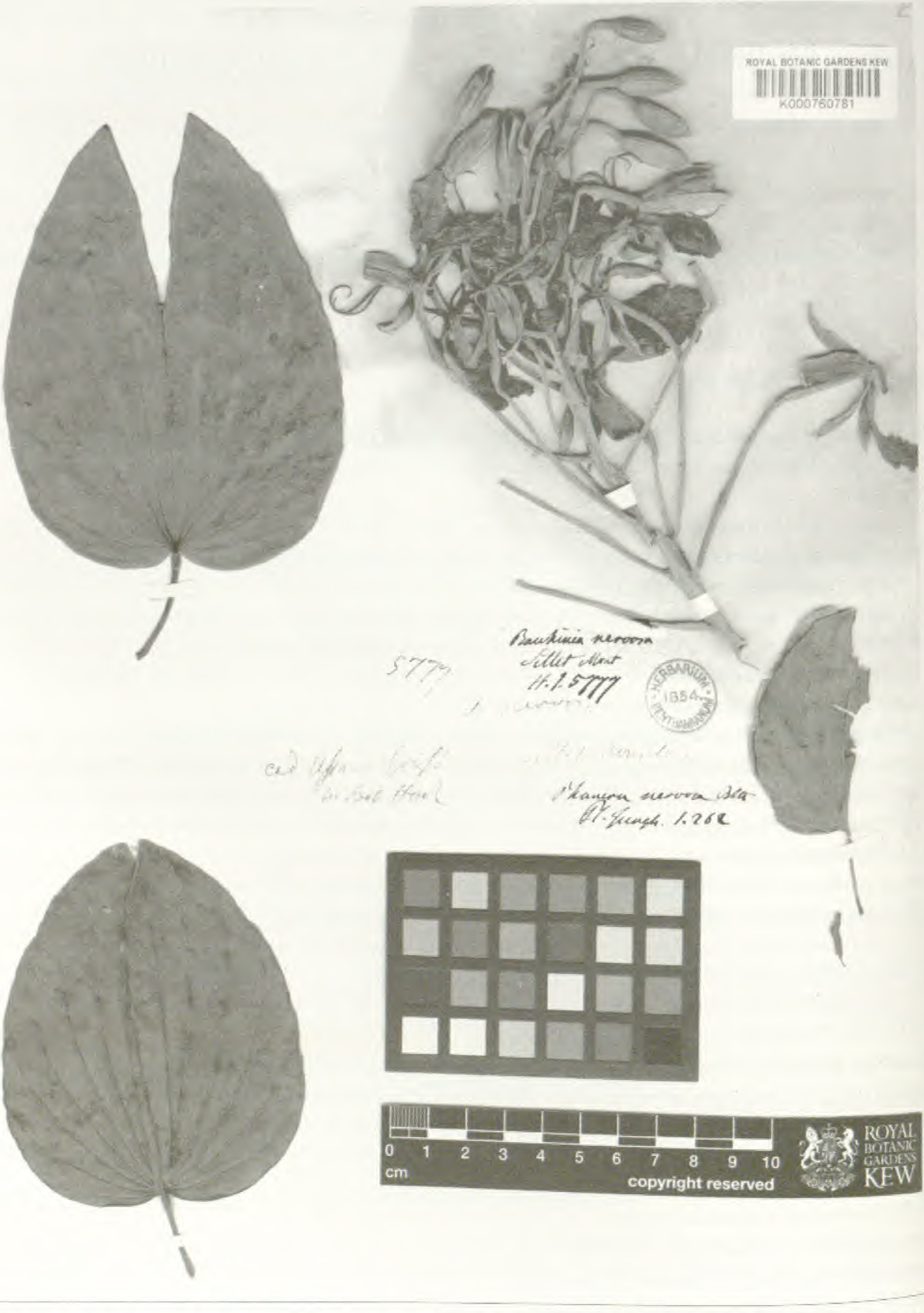
ROYAL BOTANIC GARDENS KEW
K000760781
Bauhinia nervosa
Sillet Mont
H.P. 5777
5777
HERBARIUM 1854
Phanera nervosa Bth
Pl. Jungh. 1.262
0 1 2 3 4 5 6 7 8 9 10
cm
copyright reserved
ROYAL BOTANIC GARDENS KEW

Fig. 1. Photograph of the lectotype of *Bauhinia nervosa* (Benth.) Wall. ex Baker at K. [Reproduced with kind permission of the Director and the Board of Trustees, Royal Botanic Gardens, Kew.]

Within the protologue, the "leaflets" (an error for leaf lobes) were described therein as 'acutiusculis v(el). obtusis'. In contrast to Bentham's description, Baker (1878: 283) described the leaf lobes as "sometimes subacute." Furthermore, the scandent habit that has been stated in the protologue must have been taken from some other source because the specimen neither has any tendril nor there is any such inscription on the sheet.

As no other collection of "Wall. Cat. num. list no. 5777" used by Bentham could be located, I am lectotypifying here the name with the aforementioned Kew specimen (000760781), which was originally part of 'HERBARIUM BENTHAMIANUM.'

Bauhinia nervosa (Benth.) Wall. ex Baker in J.D. Hooker, Fl. Brit. India 2:283. 1878. Type: same as of basionym *Phanera nervosa* Benth.

Phanera nervosa Benth. in Miquel, Pl. Jungh. 262. 1852. Type: Herbarium Benthamianum 1854, Sillet Mont, *N. Wallich* 5777 (lectotype, designated here: K 000760781, image! (**Fig.1**); isolectotypes: BM 000958839, image!, CAL!, K-W, image!).

Any specimen at K having the locality spelled as 'Sylhet' could not be located but it may be so that Zhang and Zhu (2006) cited the same specimen studied by me and changed the spelling of 'Sillet' to 'Sylhet' following the current usage. Although Art. 9.8 of the ICBN (McNeill et al. 2006) allows "The use of a term defined in the *Code* (Art. 9.1-9.7) as denoting a type, in a sense other than that in which it is so defined, is treated as an error to be corrected (for example, the use of the term lectotype to denote what is in fact a neotype)," Zhang and Zhu's (2006) citation 'holotype, K!' cannot be construed as an inadvertent lectotypification, even if the same specimen has been studied by us i.e. D.-X. Zhang and G.-H. Zhu and myself. This is because, Art. 7.11 of the ICBN (McNeill et al. 2006) requires that on or after 1 January 2001, the typification statement must include the phrase "designated here" (hic designatus) or an equivalent, which is not the case in Zhang and Zhu's (2006) type citation.

ACKNOWLEDGMENTS

I am thankful to the Director, Botanical Survey of India and Additional Director, Central National Herbarium, BSI for their help, to the Director, Royal Botanic Gardens, Kew for providing literature and cibachrome photograph of the Kew specimen, V.P. Prasad, IBLO, RBG, Kew for sending the image of the specimens at K-W and BM, K.N. Gandhi for refining the manuscript and to Dave Boufford and Emily W. Wood, Harvard University, USA for their comments.

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BOOK NOTICES

Germán Carnevali Fernández-Concha, José Luis tapia Muñoz, Rodrigo Duno de Stefano, and Ivón M. Ramírez Morillo. 2010. **Flora Ilustrada de la Península de Yucatán.** (ISBN: 978-607-7823-07-0, hbk.). Centro de Investigación Científica de Yucatán, A. C., Calle 43, No. 130, Colonia Chuburná de Hidalgo, Mérida, 97200, Yucatán, MÉXICO. (**Orders:** http://www.cicy.mx/libros-en-venta/listado-floristico). $250 pesos Mexicanos, 328 pp., color, 21 × 27 cm.

This exhaustively complete (to date) and thoroughly researched volume contains lists of vascular plants of Mexico's Yucatan Peninsula, including those from the states of Yucatan, Quintana Roo, and Campeche. It includes the taxa (families, genera, species, subspecies, ranks, and natural hybrids) of plants both native and naturalized, but excludes cultivated species. In all, the book provides scientific information on 2,329 taxa at the species level from 957 genera and 163 families. Locations throughout Mexico are given for each plant, and the distribution within the Peninsula is vouchered with citation of herbarium collections. The book includes color photographs.

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L.B. (Bert) McCarty and David W. Hall. 2011. **More Turfgrass and Related Weeds: Beyond the Color Atlas. A Guide to Weed Identification for Turfgrasses, Ornamentals, Plant Nurseries, Roadsides, Pastures, Specialty Areas.** (ISBN: 978-0-0798777-5-9, pbk.). Clemson University Public Service Publishing, Room 96, Poole Agricultural Center, Clemson University, Clemson, South Carolina 29634-0129, U.S.A. (**Orders:** http://www.clemson.edu/psapublishing, toll-free 1-888-772-2665, check or money order payable to Clemson University to address above). $25, 379 pp., color throughout, 7" × 10".

From the Publisher: A weed can be defined as any plant growing where it is not wanted. The first step to successful weed management is proper identification, which is the primary focus of this book, a supplement to the highly successful *Color Atlas of Turfgrass Weeds* (2nd edition).

This guide, which includes 1,118 color photographs, covers species which may be locally common but are not as widespread as those in the *Color Atlas*. Both this text and the *Color Atlas* cover most major weeds in fine and rough turfgrasses, plant nurseries, ornamentals, landscapes, pastures, roadsides, gardens, crops, and waste areas.

Carol Gracie with a foreword by Eric Lamont. 2012. **Spring Wildflowers of the Northeast: A Natural History.** 2012. (ISBN: 978-0-691-14466-5, hbk.). Princeton University Press, 41 William Street, Princeton, NJ 08540, U.S.A. (**Orders:** http://press.princeton.edu/titles/9668.html, 609-258-4884, 609-258-6305 fax). $29.95, 290 pp., 512 color illus., 7½" × 10".

From the publisher: This exquisitely illustrated volume provides an in-depth look at spring-blooming wildflowers of the Northeast, from old favorites to lesser-known species. Featuring more than 500 full-color photos in a stunning large-sized format, the book delves deep into the life histories, lore, and cultural uses of more than 35 plant species. The rich narrative covers topics such as the naming of wildflowers; the reasons for taxonomic changes; pollination of flowers and dispersal of seeds; uses by Native Americans; related species in other parts of the world; herbivores, plant pathogens, and pests; medicinal uses; and wildflower references in history, literature, and art. The photos capture the beauty of these plants and also illustrate the concepts discussed in the text.

IMPATIENS JOHNSIANA (BALSAMINACEAE), A NEW SCAPIGEROUS BALSAM FROM WESTERN GHATS, INDIA

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ABSTRACT

Impatiens johnsiana (Balsaminaceae) from the Wayanad District, Kerala, India, a new endemic epiphytic scapigerous balsam related to *I. dendricola* and *I. scapiflora*, is described and illustrated.

Key Words: Balsaminaceae, endemic species, *Impatiens johnsiana*, India, Kerala, new species, Wayanad, Western Ghats

RESUMEN

Se describe e ilustra **Impatiens johnsiana** (Balsaminaceae) de Wayanad District, Kerala, India, un nuevo endemismo epífito escaposo relacionado con *I. dendricola* e *I. scapiflora*.

INTRODUCTION

The genus *Impatiens* L. (Balsaminaceae) is a genus of over 1,000 species widely distributed throughout the Northern Hemisphere and tropics (Mabberley 2008). In India, the concentration of Impatiens species is remarkably local and occurs in two well-defined regions, viz., the Himalayas in the North and the Western Ghats in the South (Hooker 1908; Gamble 1915; Vivekananthan et al. 1997). There is no doubt that the Western Ghats is the second richest area in the Indian subcontinent and perhaps in the world (Bhaskar 1981; Viswanathan & Manikandan 2003). Out of the 203 species known to occur in India, about 86 species are found in the Western Ghats (Nair 1991). In India, scapigerous *Impatiens* form a peculiar Section '*Scapigerae*' and are restricted to the Western Ghats-Sri Lanka Hotspot of Biodiversity (Grey-Wilson 1980; Vivekananthan et al. 1997). Except for *I. acaulis* Arn., which is distributed throughout the wet tropical forests of the Western Ghats and Sri Lanka, all the other species have a very narrow distribution and are endemic to small microcenters in the Western Ghats, especially in the southern part (Kumar & Sequiera 1996; Bhaskar 2006; Jyosna et al. 2009; Anil Kumar et al. 2011).

The Wayanad district of Kerala forms a biodiversity rich area in the Nilgiri phytogeographical region of the Western Ghats. During an exploration of the flowering plants there, 21 species of *Impatiens* were collected in various habitats (Ratheesh Narayanan 2009). One, collected in a high altitude evergreen forest, was quite distinct from the hitherto known scapigerous species and it is described and illustrated here as new.

Impatiens johnsiana Ratheesh, Sunil, & Anil, sp. nov. (**Figs. 1–2**). Type: INDIA. Kerala. Wayanad District: Kattimattom Hills, ca. 1600 m, evergreen forest, 17 Aug 2010, M.K. *Ratheesh Narayanan MSSH 3671* (holotype: CALI; isotypes: MH, MSSH).

Impatienti dendricolae similis habitu pendulo, sed petalis lateraliter connatis sine auriculis (contra auriculatis), lobis basalibus curvatis lobis distalibus longioribus papillarum caespite (contra rectis ligulatis lobis distalibus brevioribus papillis), calcare plus 1.5 cm longo spirato apice lato rotundato (contra 1–1.5 cm longo erecto clavato), seminibus tuberculatis pilorum utroque caespite denso (contra muriculatis) differt. Ab *I. scapiflora* foliis pendulis elliptice oblanceolatis, pedicellis ad 2 cm longis, calcare minus 2 cm longo spirato apice lato rotundato, seminibus tuberculatis pilorum utroque caespite denso differt.

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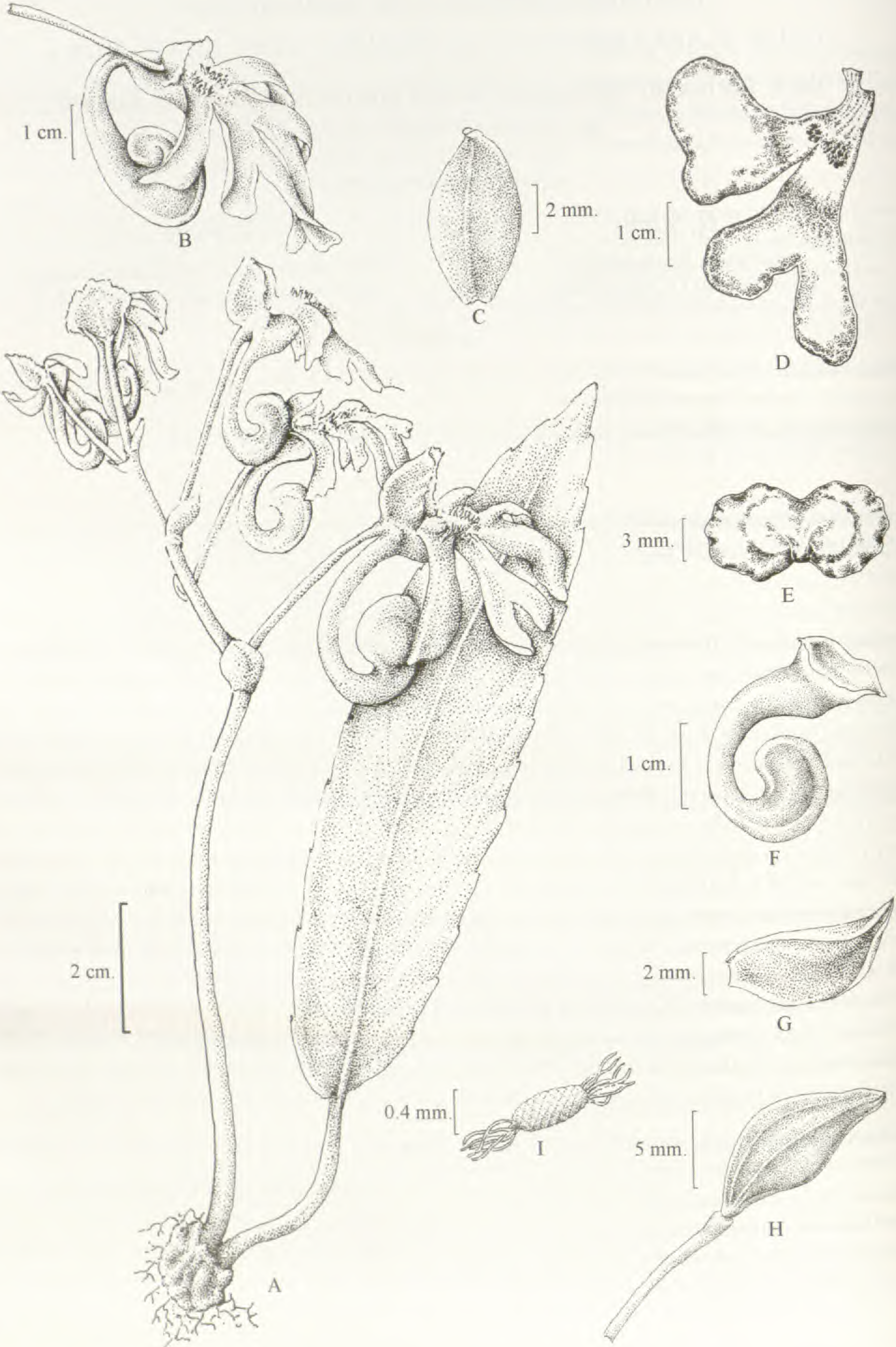
1 cm.
B
2 mm.
C
1 cm.
D
3 mm.
E
1 cm.
F
2 cm.
2 mm.
G
0.4 mm.
I
5 mm.
H
A

Fig. 1. *Impatiens johnsiana* Ratheesh, Sunil, & Anil. **A.** Habit, **B.** Single flower, **C.** Bract, **D.** Lateral united petal, **E.** Dorsal petal, **F.** Lower sepal, **G.** Lateral sepal, **H.** Fruit, **I.** Seed. Drawing by Jayesh P. Joseph and T. Shaju from living specimen.

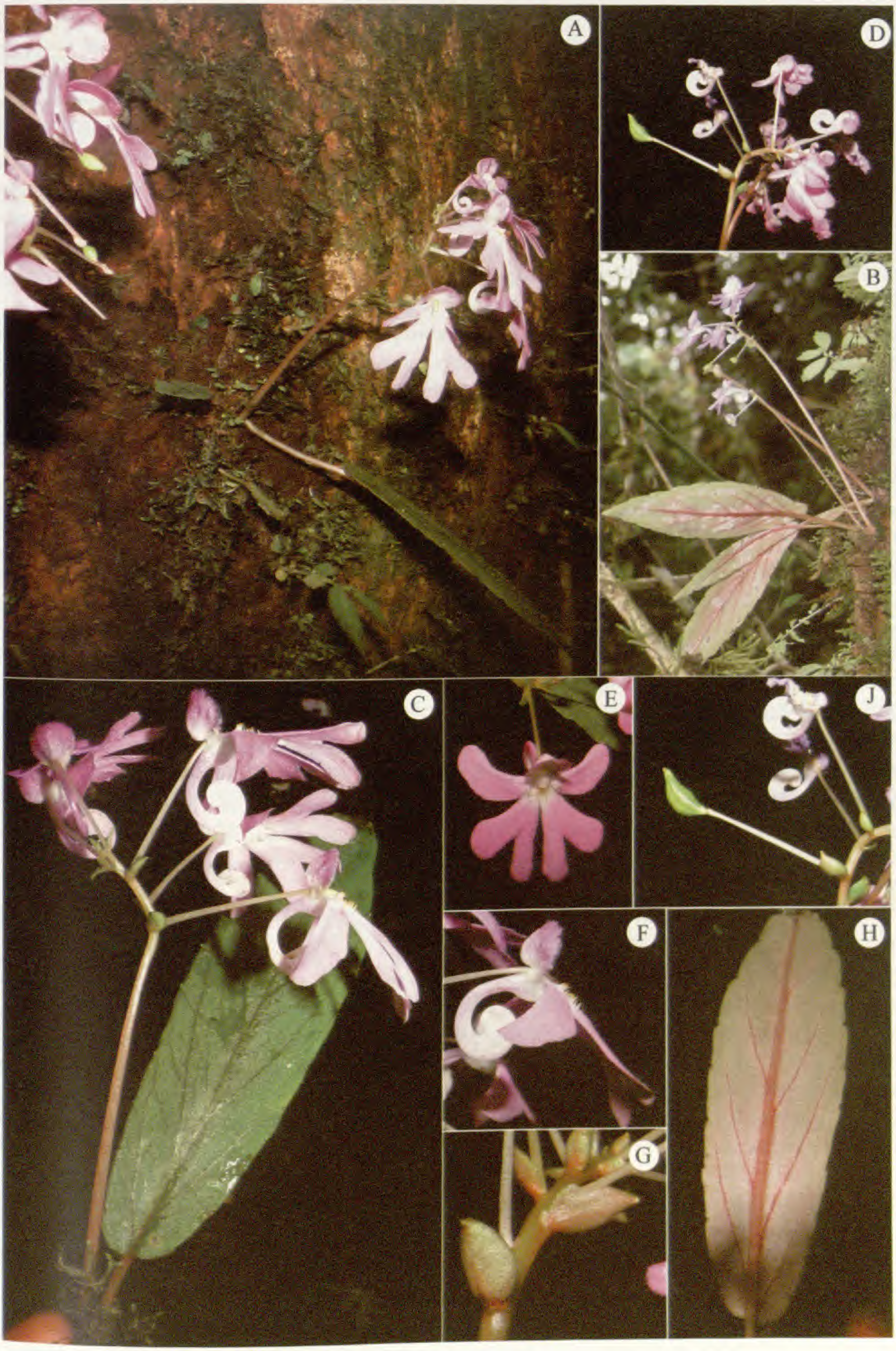

FIG. 2. *Impatiens johnsiana* Ratheesh, Sunil, & Anil. **A & B.** A population, **C.** Habit, **D.** Inflorescence, **E & F.** Flower, **G.** Bract, **H.** Leaf, **J.** Fruit.

Scapigerous perennial herbs, epiphytic, 15–22 cm tall; rootstock tuberous, yellowish. Leaves 1, rarely 2, radical, petiolate, pendulous, distantly serrate, broadly elliptic to oblanceolate, acute, mucronate at tip, base broadly cordate, unequal, 14–22 × 4–5 cm, fleshy, hairy above, glabrous below, 5–7-nerved, adaxially green, abaxially pale pink, deep pink along midrib and lateral nerves; petiole 5–8 cm long, glabrous, green above, light pink below. Inflorescence scapose, unbranched, semi-pendulous, peduncle with a bend above the middle, shorter than the leaves, 12–20 cm long, fleshy, glabrous, pink, terete, less than 10-flowered; flowers in racemes, distal, ca. 1.5 cm across, deep pink with white center; bract fleshy, light green with pink streaks, broadly ovate to oblong, 4–5 mm long, acute, glabrous; pedicels shorter than the flower, 1.6–1.8 cm long, terete, slender, white, elongating in fruit, glabrous; lateral sepal 1.7–2 × 2–2.5 mm, broadly ovate to oblong, obtuse-acute at tip, white with pink tinge, glabrous; lower sepal (lip) ca. 8 × 5 mm, white, glabrous, spurred; spur 1.5–1.7 cm long, funnel-shaped, coiled with broad tip, white, glabrous; dorsal petal (standard) broader than long, 0.5–1 cm across, hooded, glabrous, pink, margins wavy; lateral united petals 3- lobed, 1.9–2 × 1.2–1.3 cm, lobes unequal, with a tuft of yellow papillae little below the basal lobes; basal lobes larger than distal lobes, ca. 1.3 × 0.6 cm, broadly obovate, bent upwards, midlobes ca. 0.5 × 0.5 cm, straight, distal lobes ca. 0.5 × 0.5 cm, oblong, tip obtuse, straight; stamens 5, connate, ca. 2 × 1 mm, filaments pink, connate above middle, anthers pale white; ovary pale yellow, broadly elliptic, acute at apex, glabrous. Capsules broadly ellipsoid, acute, ca. 1 cm long, glabrous; seeds many, ca. 2 mm long, tubercled, with a dense tuft of hairs at each end.

PARATYPE: **INDIA. KERALA. Wayanad District:** Kattimattom hills, N11°30.716' E76°06.239' ca.1700 m, 20 Sep, 2011, *M.K. Ratheesh Narayanan, C.N. Sunil & T. Shaju MSSH* 4455 (Herb. MSSRF, Kalpetta, Wayanad).

Flowering and fruiting.—Flowering is from July with a peak in August. Fruit matured during September–October.

Etymology.—The specific epithet is in dedication to the late Prof. John C. Jacob (who was popularly known as 'Johnci'), an ardent naturalist who devoted his life to conserve the biodiversity of the Western Ghats, India.

Distribution and conservation status.—Endemic to the Kattimattom Hills of the Chembra-Vellarimala hill ranges, Wayanad District, Kerala, India. Small population of this species is distributed on densely clothed tree trunk in evergreen forests at an altitude of 1500–1700 MSL. The species is usually seen as an epiphyte on the moss-covered trunk of evergreen tree species. Our observations showed that there were less than five hundred mature individuals restricted to a 10 km^2 Vested Forest area. By following IUCN criteria (IUCN 2001) for assessing the status of Rare and Threatened plants, *Impatiens johnsiana* is assessed as belonging to Critically Endangered (CR) category. Its range (extent of occurrence) is less than 100 km^2, and the quality of habitat is declining continuously.

Taxonomic note.—*Impatiens johnsiana* resembles *I. dendricola* Fisch. in its pendulous habit, 3-lobed lateral united petals with a tuft of papillae, and seeds with a dense tuft of hairs at each end. The shape and size of leaves, color of flowers, shape and size of the lateral sepal, dorsal petal, spur and lateral united petals, and texture of seeds differentiates this species from the other. *Impatiens johnsiana* has 14–22 cm long, elliptic-oblanceolate leaves, pink flowers, broadly ovate lateral sepals, and a dorsal petal with wavy margins in contrast to the less than 10 cm long, ovate to oblong-lanceolate leaves, white flowers, falcate-ovate lateral sepals deeply lobed at base and entire dorsal petal of *I. dendricola*. The new species has 1.5–1.7 cm long, coiled spur with broad rounded apex in contrast to 1–1.5 cm long, straight, clavate spur of *I. dendricola*. The lateral united petals of the new species are not auricled, curved basal lobes larger than the distal lobes, and it has tubercled seeds. But in *I. dendricola*, the lateral united petals have an auricle, straight strap-shaped basal lobes of the lateral united petals smaller than the distal lobes, and seeds muriculate. The new species also resembles *I. scapiflora* in some of its characters, e.g., large pink flowers, lateral united petals without an auricle, and recurved basal lobes larger than the distal lobes, but differs by the pendulous elliptic-oblanceolate leaves, up to 2 cm long pedicels, less than 2 cm long, coiled spur with broad rounded apex, tubercled seeds, with a dense tuft of hairs at ends in contrast to an ovate to obovate leaf, up to 5 cm long pedicels, up to 7 cm long, tubular spur with narrow apex, and seeds hairy all over. Diagnostic morphological characters of *Impatiens johnsiana* and related species are provided in Table 1.

Table 1. Diagnostic morphological characters of *Impatiens johnsiana* and related species.

Impatiens johnsiana	*Impatiens dendricola*	*Impatiens scapiflora*
Leaves 1–2, pendulous, lamina elliptic-oblanceolate, oblique, broadly cordate at base, 14–22 cm long, petiole 5–8 cm long	Leaves 4 or 5, pendulous, lamina ovate, to oblong-lanceolate, cuneate or oblique to obtuse at base, 1.2–6 cm long, petioles 1.5–7 cm long	Leaves 2–5, erect, lamina ovate to obovate, acute, cordate to rounded at base, 7–20 cm long, petiole 4–12 cm long
Scape semipendulous, 12–20 cm long, 5–9-flowered, flowers pink	Scape erect, 5–18 cm long, 4–10-flowered, flowers white	Scape erect, 12–45 cm long, 4–16 flowered, flowers pink
Pedicels 1.6–1.8 cm long	Pedicels 1–2 cm long	Pedicels 2–5 cm long
Lower sepals broadly elliptic, white	Lower sepals broadly ovate, white	Lower sepals saccate, pink
Spur coiled, with broad rounded apex, 1.5–1.7 cm long, white	Spur clavate, straight, rounded at apex, 1.3–1.5 cm long, white	Spur tubular, curved, very narrow at apex, 5–7 cm long, pink
Lateral united petals 1.9–2 cm long, not auricled, pink with a tuft of yellow papillae little below the basal lobes	Lateral united petals 1.6–2 cm long, auricled, white with yellowish brown to orange papillae	Lateral united petals 2.3–3.5 cm long, not auricled, pink, without papillae
Basal lobes of lateral united petals larger than the distal lobes. Capsules broadly ellipsoid, seeds tubercled, with a dense tuft of hairs at ends	Basal lobes of lateral united petals smaller than the distal lobes. Capsules ellipsoid or oblanceoloid, seeds muriculate with tuft of hairs at ends	Basal lobes of lateral united petals larger than the distal lobes. Capsules lanceoloid, seeds hairy all over

ACKNOWLEDGMENTS

The authors are grateful to the Chairman Prof. M.S. Swaminathan and Executive Director of the M.S. Swaminathan Research Foundation, Chennai, India, for providing facilities and support. The logistics provided by the Kerala Forest Department for the fieldwork and the help rendered by K.T. Satheesh, V.R. Volga, V. Mini, Jithin M.M., and S. Mithunlal, Community Agrobiodiversity Centre, M.S. Swaminathan Research Foundation, Kalpetta are thankfully acknowledged. Sincere thanks are expressed to J.F. Veldkamp (L) for critical remarks and the Latin diagnosis, Anil Zakharia and Sethu Madhavan for the field support and encouragement. Two anonymous reviewers provided constructive and helpful reviews.

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COMMELINA CLAVATOIDES (COMMELINACEAE), A NEW SPECIES FROM KERALA, INDIA

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ABSTRACT

A new species of Commelinaceae, **Commelina clavatoides,** is described from Kerala, India. It is closely allied to *C. clavata* C.B. Clarke, but differs by its long internodes, leaf and peduncle, antherode with a cream or purple spot at the centre, free sepals, 5–6 capsules per spathe and shallow-pitted, ovoid to oblong seeds.

Key Words: Commelinaceae, *C. clavatoides*, India

RESUMEN

Se describe una especie nueva de Commelinaceae, **Commelina clavatoides,** de Kerala, India. Está íntimamente relacionada con *C. clavata* C.B. Clarke, pero se diferencia por sus largos internudos, hoja y pedúnculo, anterodio con una mancha crema o purpura en el centro, sépalos libres, 5–6 cápsulas por espata y semillas con punteaduras poco profundas, de ovoides a oblongas.

INTRODUCTION

Commelina L. comprises about 170 species (Faden 1998) of which 24 species were reported from India (modified after Karthikeyan et al. 1989). As part of the ongoing studies on the revision of *Commelina* in India, the authors have made extensive explorations in various parts of India since 2002. The specimens of this species were first collected in 2002 from Paithalmala, a grassy hill slope in northern Kerala. It remained in cultivation in the Botanical Garden of St. Joseph's College for a long time, but subsequently perished. However, after a lapse of seven years, the third author collected this species again from another hill tract in southern Kerala, almost 300 km from the first locality. Since then, we have collected this species from a few more localities in Kerala. This taxon is unique in having 5–6 capsules per spathe and shallow-pitted, ovoid to oblong seeds and is here described as a new species: *Commelina clavatoides*.

Commelina clavatoides Nampy & S. Joseph, sp. nov. (**Figs. 1–2**). Type: INDIA. Kerala: Idukki district, Adimali-Munnar roadside, 19 Nov 2010, *Sheba M. Joseph & Santhosh Nampy 4016* (holotype: DEV; isotypes: BRIT, CALI).

Commelina clavatoides is similar to *C. clavata* C.B. Clarke, but differs from the latter by the 6–10 cm long peduncles, free lateral sepals, 5–6 capsules per spathe and shallow-pitted, ovoid to oblong seeds as opposed to the 2.5–4.5 cm long peduncles, basally fused lateral sepals, 2 or rarely 3 capsules per spathe and shallow-reticulate, elliptic seeds seen in *C. clavata*.

A much-branched, extensively scrambling, probably perennial herb with a definite base; roots long, thick, fibrous. Stem terete, ca. 8 mm in diam., green with red striations; internodes 6–15 cm long. Leaves distichous; sheath ca. 3 cm long, strigose, ciliate at apex, mottled with red striations; lamina narrowly lanceolate, 10–14 × 1–2 cm, acuminate at apex, cuneate at base, serrulate at margins, upper surface scabrous, lower surface glabrous. Spathe broadly cordate, 4–5.5 × 1.5 cm, conduplicate, acute at apex, ciliate towards base, puberulent on both surfaces, lower half pale green, upper half dark green; peduncle 6–10 cm long, green, strigose, leaf-opposed. Upper cincinnus 2–2.5 cm long, exerted, ciliate, 1 or rarely 2 male flowered; lower cincinnus 1.5–2 cm long, glabrous, 6 or 7 bisexual flowered. Sepals free, transparent, anterior boat-shaped, narrowed at apex, posterior sepals oblong. Petals bright blue; paired petals orbiculate, claws 2 mm long; medial petal deltoid, claw 1 mm long. Staminodes 3, equal; filaments slender; antherode yellow, 4-lobed with 2 lateral appendages; central

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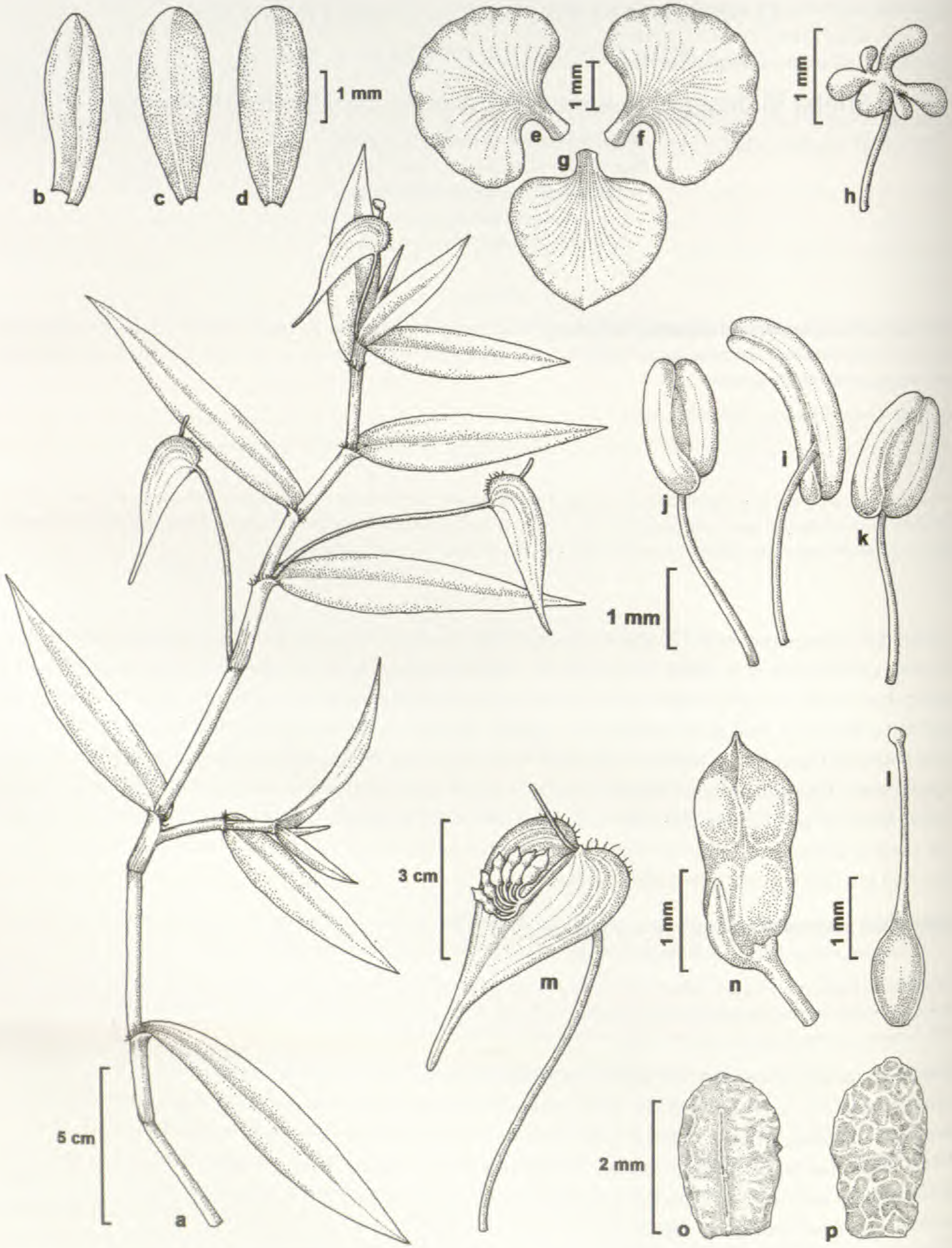
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Fig. 1. *Commelina clavatoides* Nampy & S. Joseph. **a.** Flowering twig, **b.** Anterior sepal, **c–d.** Posterior sepals, **e–f.** Paired petals, g. Medial petal, **h.** Staminode, **i.** Medial stamen, **j–k.** Lateral stamens, **l.** Gynoecium, **m.** Spathe with capsules, **n.** Capsule, **o.** Seed in ventral view, **p.** Seed in dorsal view (Drawn by K.M. Manudev from *Sheba M. Joseph & Santhosh Nampy 4016*).

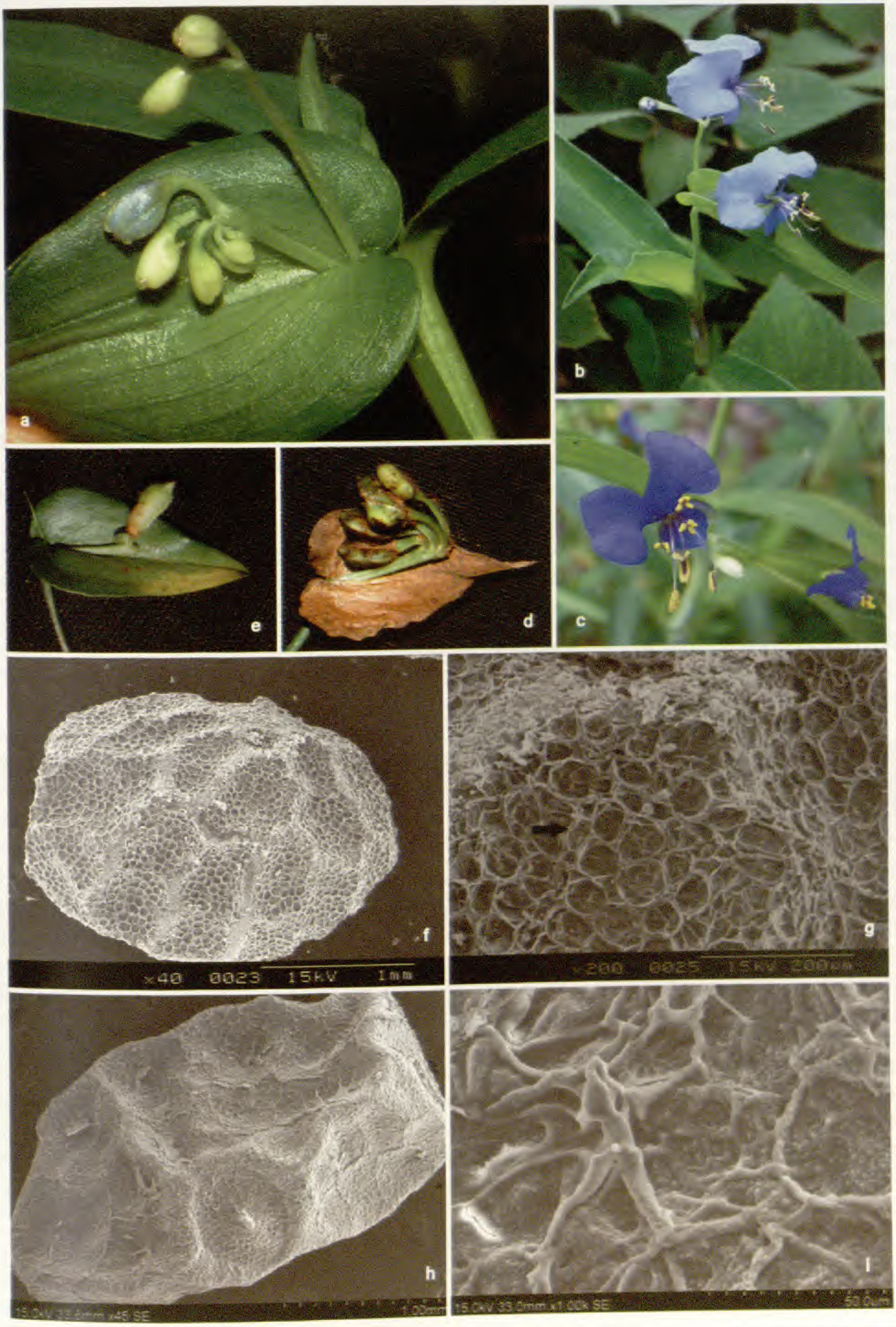
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Fig. 2 (a–d, h & i). *Commelina clavatoides* Nampy & S. Joseph. **a.** Spathe with cincinni and flower buds, **b.** Spathe with upper and lower cincinni bearing opened flowers, **c.** Flower, **d.** Spathe with mature capsules, **h–i.** SEM of seeds; (e–g). *Commelina clavata* C.B. Clarke, e. Cincinni with capsule, f–g. SEM of seeds. (Photos b & c by K.M. Prabhu Kumar)

Table 1. Morphological differences between *C. clavata* and *C. clavatoides*.

Characters	*C. clavata*	*C. clavatoides*
Internode	7–9 cm long	6–15 cm long
Lamina size	3–10 × 0.4–1.5 cm	10–14 × 1–2 cm
Color of spathe	Green throughout	Upper half dark green, lower pale green
Spathe size	2–4 × 0.7 cm	4–5.5 × 1.5 cm
Peduncle	2.5–4.5 cm long	6–10 cm long
Lower cincinnus:		
No. of flowers & indumentum	2–3, ciliate	6–7, glabrous
Fusion of lateral sepals	Basally fused	Free
Color of antherode	Yellow with a maroon central spot	Yellow with a cream or purple central spot
No. of capsules in spathe	2 or rarely 3 per spathe	5–6 per spathe
Seed shape	Elliptic	Ovoid to oblong
Testa ornamentation	Shallow, reticulate	Shallow, pitted

spot cream or purple. Stamens 3; lateral stamens with straight anther, medial stamen with curved anther. Ovary elliptic, green; style white, 3 mm long, slightly curved; stigma capitate. Capsules 5–6 per spathe, oblong, compressed, bilocular; dorsal locule absent; ventral locules 2-seeded. Seeds ovoid to oblong, ca. 3 × 1 mm, testa black, pitting shallow, hilum linear, embryotega lateral.

Paratypes: **INDIA. Kerala. Idukki district:** Marayoor, 21 Oct 2009, *Santhosh Nampy 2293* (DEV). **Kannur district:** Paithalmala, 14 Sep 2002, *Santhosh Nampy & Joby Paul 829* (DEV). **Kozhikode district:** cultivated, Devagiri College Botanical Garden, 03 Dec 2011, *Sheba M. Joseph 4044* (DEV). **Palakkad district:** Nelliyampathy, 19 Nov 2010, *Shahina P.M. & Sheba M. Joseph 4024* (DEV).

Flowering & fruiting.—September–November; flowers opening from 9.00 am–12.00 pm

Ecology.—Usually adapted to high altitude (above 1750 m). It grows on vertical earth cuttings along the margins of wet evergreen forest.

Etymology.—The epithet *clavatoides* indicates the similarity of the new species to *C. clavata* C.B. Clarke. Both species have scabrous leaf, ciliate, navicular spathe and 4-seeded capsules. The two species are separated by the characters listed in Table 1.

ACKNOWLEDGMENTS

The authors are grateful to C.J. Mani, Head, Dept. of Botany and Principal, St. Joseph's College, Devagiri for facilities; K.M. Manudev for illustrations; P.M. Shahina for accompanying collection trips; K.M. Prabhu Kumar for a few photographs; Department of Nanotechnology, National Institute of Technology, Kozhikode for SEM of seeds. One of us (SMJ) is thankful to the University Grants Commission, New Delhi for Teacher Fellowship. The Principal and Manager, St. Mary's College, Sulthan Bathery for permission to undertake Faculty Improvement Program. John Conran provided helpful review comments.

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A MID-TERTIARY FOSSIL FLOWER OF *SWIETENIA* (MELIACEAE) IN DOMINICAN AMBER

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ABSTRACT

We report a further example of an amber-embedded flower representative of Mid-Tertiary tropical forests from the Caribbean island of Hispaniola. The new fossil species **Swietenia dominicensis** (Meliaceae) consists of a functionally staminate flower whose urceolate filament tube bears 10 deltate-acuminate appendages. Within the mouth of the tube are 10 sessile stamens alternating with the appendages. The slightly exserted style bears a conspicuous disc-shaped stigma the surface of which is obscurely 5–6 segmented and minutely pitted. The perianth combines ciliolate calyx lobes with glabrous-margined petals, unlike any of the 3 modern species of *Swietenia*. The glabrous petals, as well as the form of the calyx, distinguish this flower from the Mexican fossil species *Swietenia miocenica* described by Castañeda-Posadas and Cevallos-Ferriz (2007).

RESUMEN

Citamos otro ejemplo más de flor incluida en ámbar representativa de los bosques tropicales del Terciario medio de la isla caribeña la Hispaniola. La nueva especie fósil **Swietenia dominicensis** (Meliaceae) consiste en una flor funcionalmente estaminada cuyo tubo urceolado lleva 10 apéndices deltado-acuminados. En la boca del tubo están 10 estambres sésiles alternando con los apéndices. El estilo ligeramente exerto lleva un estigma en forma de disco cuya superficie está oscuramente dividida en 5–6 segmentos y punteada diminutamente. El perianto combina lóbulos del cáliz ciliolados con pétalos glabros en los márgenes, a diferencia de las 3 especies modernas de *Swietenia*. Los pétalos glabros, así como la forma del cáliz, distinguen esta flor de la especie fósil mexicana *Swietenia miocenica* descrita por Castañeda-Posadas y Cevallos-Ferriz (2007).

INTRODUCTION

The flower described here as *Swietenia dominicensis* was illustrated incidentally by Poinar and Poinar (1999, p.19) in their book reconstructing the Late Oligocene-Early Miocene tropical forests of Hispaniola. It supplements the 9 species of fossil flowers thus far reported from amber mines in the Dominican Republic. The other described species of amber-embedded flowers are in the genera *Hymenaea* (Fabaceae) (Poinar 1991), *Trithrinax*, *Paleoraphe*, and *Roystonea* (Arecaceae) (Poinar 2002a, 2002b), *Licania* (Chrysobalanaceae) (Poinar et al. 2008a, revised by Chambers & Poinar 2010), *Persea* (Lauraceae) (Chambers et al. 2011a), *Trichilia* (Meliaceae, 2 species) (Chambers et al. 2011b), and *Trochanthera* (possibly Moraceae) (Poinar et al. 2008b). The flower of *Swietenia dominicensis* is similar in most respects to the 3 extant species of the genus (Styles 1981) and to *Swietenia miocenica* described from Mexican amber by Castañeda-Posadas and Cevallos-Ferriz (2007). Its distinguishing morphological trait is the combination of ciliolate calyx lobes with glabrous-margined petals, the other taxa having either the calyx and petals both ciliolate, or all perianth parts glabrous-margined. This minor difference is important in the taxonomy of the genus, although its usefulness in classification was questioned by Miller (1990, p. 479), who, however, misinterpreted the species differences as given by Styles (1981, p. 391). Other features, such as size of leaflets and petiolules, seed color, and capsule size, cannot be characterized for the fossil species. *Swietenia miocenica* was reported to have a calyx of 5 free lobes, whereas the species at hand, as well all living members of the genus, have a calyx “5-lobed to about the middle” (Styles 1981, p. 389).

MATERIALS AND METHODS

Like the several fossil species from the Dominican Republic cited above, the flowers originated from amber mines in the Cordillera Septentrional, between the cities of Puerto Plata and Santiago. The age of these deposits

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has proven to be controversial, the oldest proposal being 45–30 mybp, based on coccoliths (Cêpek in Schlee 1999) and the youngest being 20–15 mybp, based on foraminifera (Iturralde-Vinent & MacPhee 1996). The amber is principally deposited in turbiditic sandstones of the Upper Eocene to Lower Miocene Mamey Group (Draper et al. 1994).

DESCRIPTION

Swietenia dominicensis K.L. Chambers & Poinar, sp. nov. (**Figs. 1–3**). TYPE: HISPANIOLA. DOMINICAN REPUBLIC: amber mine in the northern mountain range (Cordillera Septentrional), 1995, *unknown amber miner s.n.* (HOLOTYPE: catalogue number Sd-9-7, deposited in the Poinar amber collection maintained at Oregon State University, Corvallis, Oregon 97331, U.S.A.).

Flower putatively staminate, total length (pedicel apex to tip of filament tube appendages) 3.85 mm, calyx shallowly cupulate (Fig. 2), ca. 1.0 mm long, fused portion 0.54 mm long, lobes 0.45 mm long, broadly rounded, spreading, margins ciliolate, petals 5, free, ca. 4.5 mm long, 2.2 mm at widest part, spreading or reflexed, somewhat contorted, elliptic to oblanceolate, obtuse, glabrous (including margins), filament tube urceolate (Fig. 1), glabrous, 2.9 mm long excluding appendages, 2.9 mm wide, appendages 10, deltoid-acuminate, ca. 0.8 mm long, slightly spreading, anthers 10, sessile, alternating with appendages, ca. 0.6 mm long (only a few visible for measurement), dehisced, hypothesized to be fertile, pistil present, ovary not visible, style exserted from filament tube, barely exceeding appendages, stigma enlarged, disc-shaped, 1.3 mm in diameter, densely minutely pitted, obscurely marked into 5–6 fused segments (Fig. 3).

Etymology.—From the amber's source in the Dominican Republic.

DISCUSSION

We hypothesize that the flower is staminate in function, although its anthers are dehisced and are not well enough displayed to be sure that pollen was produced. The flower's overall shape, including the position and morphology of the stigma, matches well the excellent drawings of staminate flowers of *Swietenia mahagoni* published by Miller (1990, p. 478). We also compared it with illustrations of the other modern species, *S. humilis* and *S. macrophylla*, in Styles (1981) and with the description and photographs of the Mexican fossil species, *S. miocenica*, in Castañeda-Posadas and Cevallos-Ferriz (2007). Together with the examination of herbarium material of *S. mahagoni*, these references support our judgment that the Dominican fossil is best placed in *Swietenia*.

As noted by Styles (1981) and other authors (e.g. Helgason et al. 1996), the 3 modern species of the genus are "poorly defined biologically," are largely allopatric at the present time, and are "reasonably distinct morphologically" (Styles 1981). Putative hybrids, from the natural zones of contact in Costa Rica and Guatemala involving *S. humilis* and *S. macrophylla*, are intermediate for both ecological tolerance and morphological characters such as rachis length and leaflet size (Whitmore & Hinojosa 1977; Helgason et al. 1996). An extensive polyploid series of chromosome numbers is reported for the genus (Khosla & Styles 1975; Helgason et al. 1996). A further complication is that *S. mahagoni*, in particular, has been widely planted outside its original range in southern Florida and the larger Caribbean islands, thereby increasing the occurrences of species sympatry. The key distinction that we relied on to separate the present fossil from all other species is its combination of a ciliolate calyx with glabrous-margined petals. *Swietenia mahagoni* is described as having glabrous calyx lobes and petals, while the other 2 species under discussion have ciliolate petals and calyx (Styles 1981). Miller's remark (1990, p. 479) that "this distinction was not apparent in numerous specimens … that I studied" is offset by his statement, perhaps in error, that the calyx and corolla are ciliolate in *S. mahagoni* and smooth-margined in the other 2 species. Nonetheless, the differences in perianth pubescence described by Styles (op. cit.) have held true in practice (Pennington, pers. obs.).

Castañeda-Posadas and Cevallos-Ferriz (2007) differentiated *Swietenia miocenica* from this Dominican fossil, which they saw illustrated, but not described, in Poinar and Poinar (1999), by differences in the shape of the filament tube and petals. In addition, they described *S. miocenica* as having "a free calyx composed of five… rounded lobes …," which would differentiate it from all other known species of the genus. To their species characterization we have added the lack of petal ciliolation in *S. dominicensis* versus its presence in *S. miocenica*. The age of *S. miocenica* given by these authors (Late Oligocene-Early Miocene, 26.0–22.3 mybp) approxi-

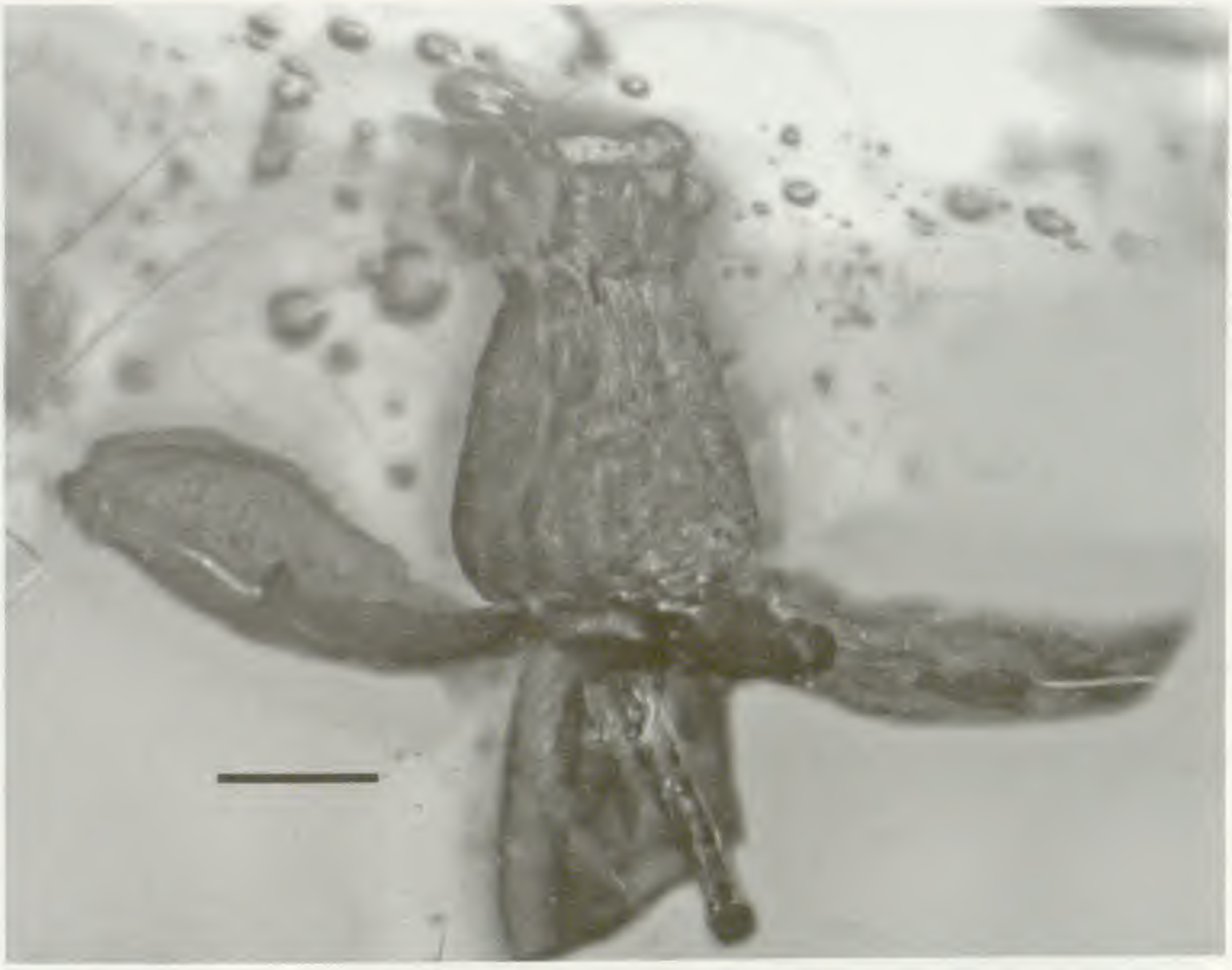

FIG. 1. *Swietenia dominicensis*. Flower in lateral view, showing anther tube with acuminate distal lobes, slightly exserted style, and capitate, discoid stigma. Black ovals on 2 petals are air bubbles. Scale bar = 1.5 mm.

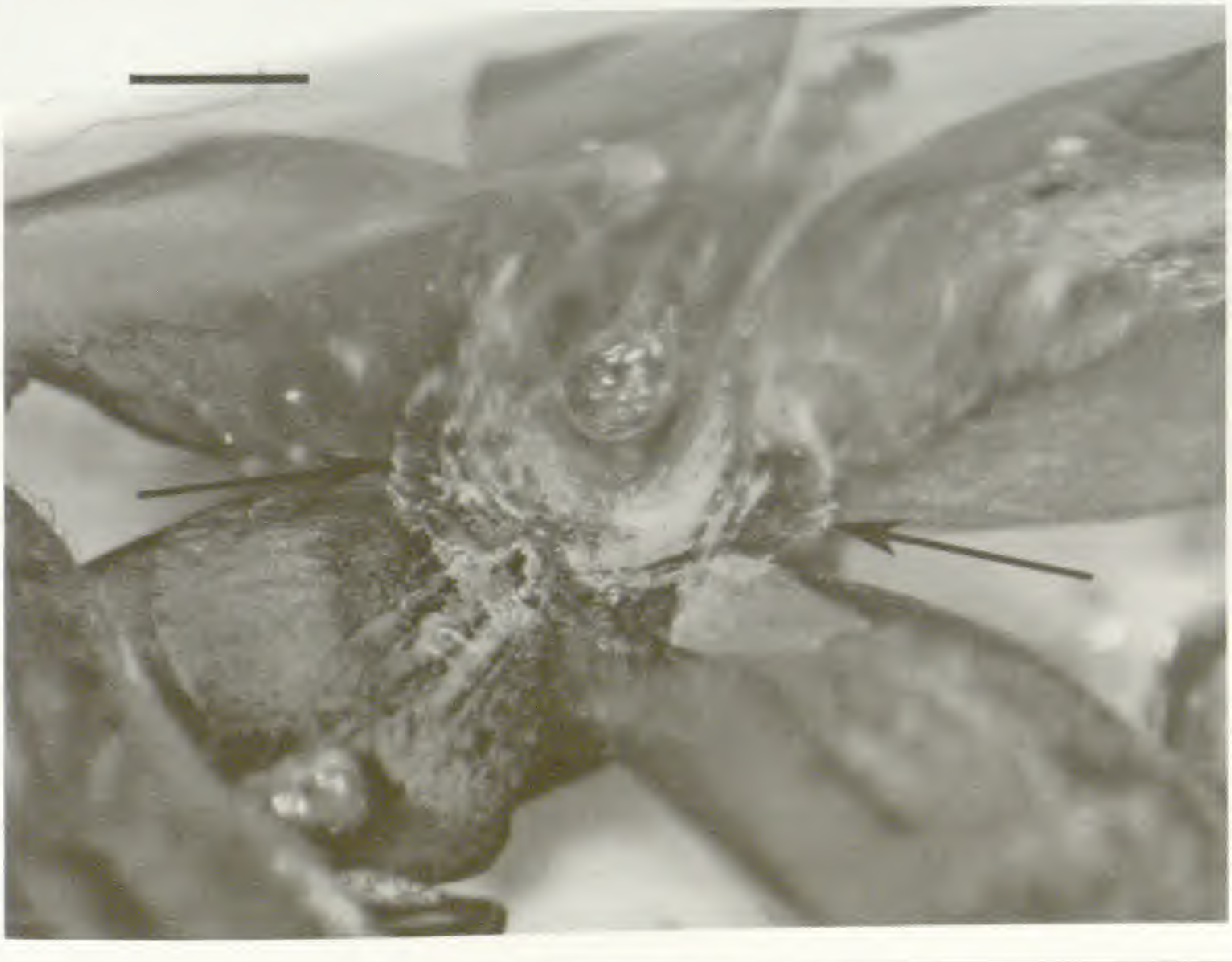

FIG. 2. *Swietenia dominicensis*. Basal view of flower with pedicel in center. Arrows indicate 2 of 3 sepal lobes in focus. Sepal lobes ciliolate-margined, petals glabrous-margined. Scale bar = 0.45 mm.

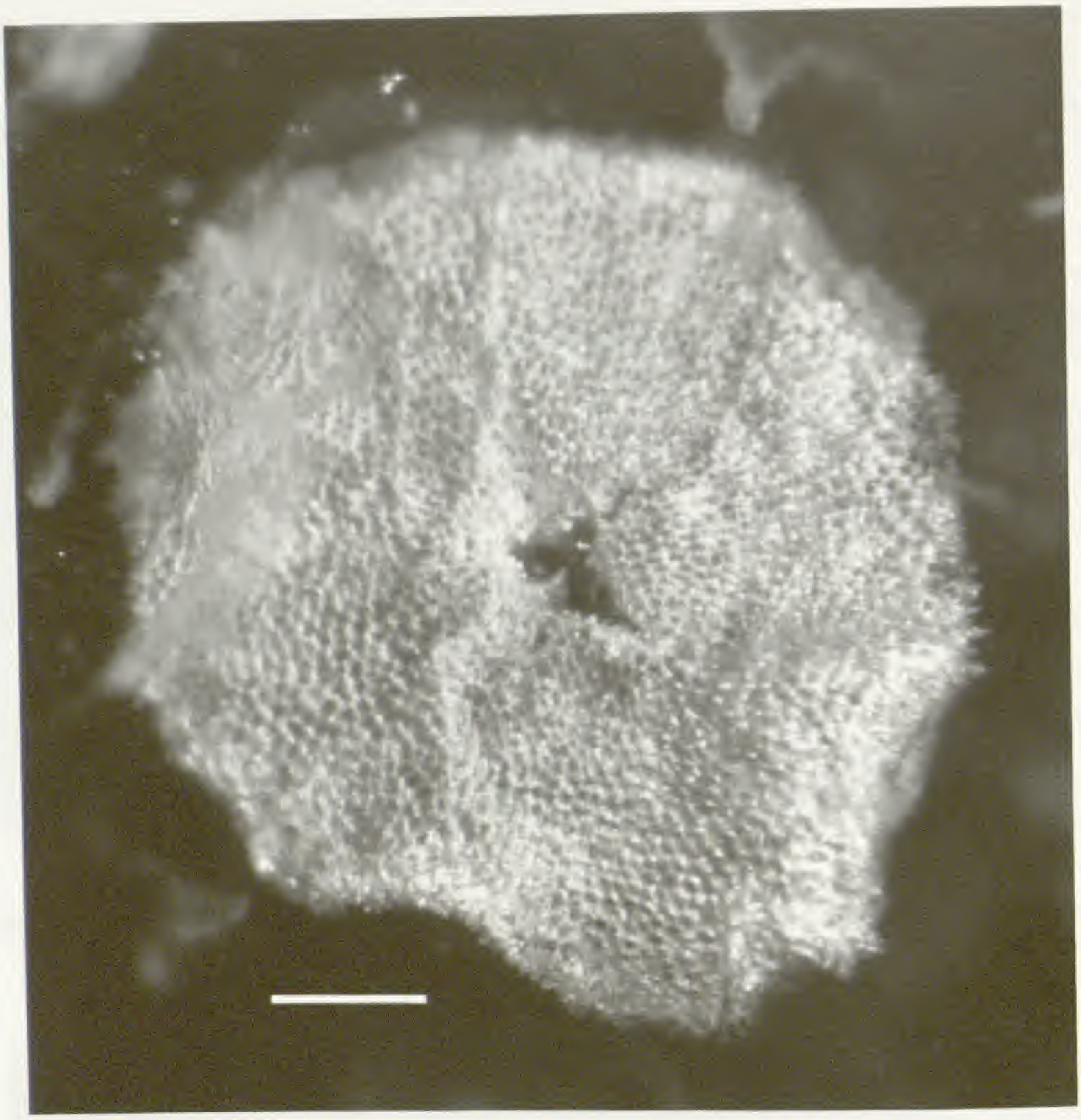

Fig. 3. *Swietenia dominicensis*. Stigmatic head of pistil. Note minute pores and irregular division into indistinct segments. Scale bar = 0.24 mm.

mates that of *S. dominicensis*. Nonetheless, we conclude that *S. dominicensis* is best described as a separate species, especially given the different provenance and the morphological details of calyx, filament tube, and perianth pubescence.

Swietenia is placed in the monophyletic subfamily Cedreloideae (formerly Swietenioideae) by Muellner et al. (2003, 2006). However, compared with the tribe Cedreleae, composed of *Cedrela* and *Toona* (Muellner et al. 2009), the remaining tribes Swietenieae and Xylocarpeae, as described by Pennington and Styles (1975), are not monophyletic (Muellner et al. 2003, 2006). *Capuronianthus* had previously been classified as a separate subfamily by Pennington and Styles (1975), but was later shown to be nested within Cedreloideae (Muellner et al. 2003). According to Muellner et al. (2003), "some genera and most tribes can only be diagnosed by using a combination of several characters." A well resolved and sufficiently supported molecular phylogenetic reconstruction including all genera of Cedreloideae (compare Muellner et al. 2011 for a recent test of more DNA markers in *Cedrela*, *Swietenia*, and other genera), along with a detailed morphological re-investigation, will ultimately lead to a new and robust tribal classification within Cedreloideae.

Muellner et al. (2006) discussed the fossil history of Meliaceae as a whole, with later reviews, in greater detail, for tribe Cedreleae (Muellner et al. 2009, 2010; Pennington & Muellner 2010). Fossils of Cedreleae have been reported from the Eocene and later periods, at both northern and mid-latitude sites in the Old and New Worlds. In proposing a West Gondwanan origin for family Meliaceae (Muellner et al. 2006), the authors discussed an "out-of-Africa" scenario, "with dispersal….[via] important routes across Eurasia and between Eurasia and North America provided by Beringia and the North Atlantic land bridge, and between North America and South America through island chains and/or direct land connections." A crown group age for *Swietenia* has not yet been proposed. Based on fossil evidence (Europe, North America) and relaxed molecular clock dating, crown Cedreleae are believed to date back at least to the Early Eocene (Muellner et al. 2010; Pennington & Muellner 2010). The Late Oligocene-Early Miocene age of our fossil and that of Castañeda-Posadas and Cevallos-Ferriz (2007) verifies the Mid-Tertiary occurrence of *Swietenia* in Central and South America.

ACKNOWLEDGMENTS

We thank the herbaria of Harvard University and The New York Botanical for their loan of specimens used in this study. The valuable review comments of Terence D. Pennington and Alexandra N. Muellner are gratefully acknowledged.

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BOOK REVIEW

Charles M. Allen, Kenneth A. Wilson, and Harry H. Winters. 2011. **Louisiana Wildflower Guide.** (ISBN: 978-0-9718625-3-1, pbk.). Allen's Native Ventures, LLC, 5070 Hwy 399, Pitkin, Louisiana, 70656, U.S.A. (**Orders:** www.nativeventures.net, 337-328-2252). $30, 246 pp., 500 + color photos.

Louisiana Wildflower Guide is a welcome addition to the libraries of Louisiana botanists. Previously, professional botanists and plant lovers in Louisiana relied on the broader regional field guides for identifying local plants. With this publication, Louisiana finally has a dedicated field guide to its abundant wildflowers.

The book is divided into sections for monocots and dicots and then alphabetically by family and genus. Each plant gets a paragraph that includes a technical description with notes on habitat, parish records, and synonymy. Each species also has a high-quality color photograph. Those trying to identify and learn plants for the first time will appreciate the many charts provided to help narrow down your identification. For example, some of the charts included, list monocot genera that are annuals, list of monocot genera that are scapose, list of dicot genera with lavender flowers, and several other lists. This will lead the identifier to the index to find the page with photo and description. Because the authors chose not to arrange the book by flower color, like so many field guides commonly do, this is a nice format. Indeed, flower color can vary by species and among genera. Further, field guides organized by flower color can disassociate related plants. With the format of this guide, the user is more likely to narrow the plant down to the generic level, thus leading them to the section of the book where all the species of that genus are discussed. The book also contains color photos of various habitat types (marsh, prairie, swamp, pine forest), a glossary of botanical terms, and line drawings of many of the botanical terms.

As stated in the book's introduction, the authors have aimed to provide a guide to Louisiana's wildflowers that "... split(s) the difference between the technical and too simple." The book succeeds in doing so and I expect it will gain wide readership considering that *All About Louisiana Wildflowers* by Jan Midgley (2003) is geared toward gardeners and *Wildflowers of Louisiana and Adjoining States* by Clair Alan Brown (1980) is long out of print. I would recommend this book to anyone working in Louisiana and East Texas. It is small enough to fit in your backpack, but covers enough species to take it beyond a simple roadside plants guide.

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BOOKS RECEIVED/REVIEWS FORTHCOMING

Zsolt Debreczy and István Rácz. Edited by Kathy Musial. 2011. **Conifers Around the World. Volumes 1 and 2.** (ISBN: 978-963-219-063-1 [vol. 1], 978-963-219-064-8 [vol. 2], 978-963-219-061-7 [vols. 1–2], hbk.). DendroPress, Ltd., Budapest, Hungary. (**Orders:** www.dendropress.com). $250.00, 2 volumes, 1089 pp. 474 range maps, nearly 1300 illustrations, more than 3700 color photos, 9.25" × 10.25".

Stunningly beautiful!

Michael Wojtech. Forword by Tom Wessels. 2011. **Bark: A Field Guide to Trees of the Northeast.** (ISBN: 978-1-58465-852-8, pbk.). University Press of New England, One Court St., Suite 250, Lebanon, New Hampshire 03766, U.S.A. (**Orders:** www.upne.com). $24.95, 264 pp., color throughout, 5.5" × 8.75".

CORRIGENDA:
A NEW SPECIES OF *ERIGERON* (ASTERACEAE) FROM SOUTHWESTERN OREGON

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Corrigenda

In my paper *A new species of* Erigeron *(Asteraceae) from southwestern Oregon*, J. Bot. Res. Inst. Texas 5:415–419, 2011, the species epithet in the description, p. 415, was misspelled as *"stansellii"* rather than the correct *"stanselliae."*

REFERENCE

CHAMBERS, K.L. 2011. A new species of *Erigeron* (Asteraceae) from southwestern Oregon. J. Bot. Res. Inst. Texas 5:415–419.

BOOK REVIEW

John W. Tunnell Jr., Jean Andrews, Noe C. Barrera, and Fabio Moretzsohn. 2010. **Encyclopedia of Texas Seashells: Identification, Ecology, Distribution, and History.** (ISBN: 978-1-60344-141-4, hbk.). Texas A&M University Press, John H. Lindsey Bldg,, Lewis St. 4354 TAMU, College Station, Texas 77843-4354, U.S.A. (**Orders:** www.tamupress.com, 800-826-8911). $50.00, 512 pp., 8.5" × 11".

Contents: 1) Shells in Texas Coastal History. 2) Chronology of Marine Malcology in Texas. 3) Molluscan Ecology and Habitats. 4) Collecting Seashells. 5) General Features of Mollusks. 6) Texas Seashells. 7) Class Aplacophora; a-Class Polyplacophora (Chitons); b-Class Gastropoda (Snails); c-Class Cephalopoda (Squid, Octopus); d-Class Bivalvia (Bivalves); e-Class Scaphopoda (Tusk Shells). 8) Appendix: Outline of Classification and Checklist of Texas Seashells. 9) Glossary. 10) References. 11) Index.

Encyclopedia of Texas Seashells is just that: an encyclopedia providing everything an amateur, naturalist, or researcher would need regarding Texas seashells. While perhaps written with a scientific audience in mind, this text is accessible to a wide range of audiences. This book is 8.5 × 11inches, hardbound, and the size and weight of a textbook; it is not a field guide by any means. The book is full of 987 color photographs, 12 black and white photos, 15 maps, 18 line drawings, several figures and tables, and a complete glossary, bibliography, and index.

Chapter 1, Shells in Texas Coastal History, provides a brief summary of geologic history of coastlines and how they formed, as well as a summary of the uses (construction, tools, ornaments, food, etc.) of seashells dating back to the early Archaic era (over 4,500 years ago).

Chapter 2, Chronology of Marine Malacology in Texas, provides a list of texts on malacology in chronological order, and then discusses some of the scientists instrumental to the field.

Chapter 3, Molluscan Ecology and Habitats, provides a physical description of the Texas coast with black and white maps and a few color photographs. This section describes the bays and estuaries and the rivers that flow into them. The next section discusses the factors that affect mollusk distribution, e.g. temperature, seasons, salinity, turbidity, etc. There are ecological descriptions of habitats (coastal marshes, bay bottoms, reefs, sea meadows, flats, jetties, beaches, banks, etc.) where mollusks can be found. These descriptions include species of mollusk common in that habitat, typical vegetation type, temperature, salinity, and predator-prey interactions within these habitats. Also included are color plates with images of the species assemblages typical of each habitat.

Chapter 4, Collecting Seashells, contains very brief descriptions of how to collect, maintain, buy, sell, and trade shells. Lacking from this section is a suggested listing of necessary data if you are collecting shells for scientific purposes.

Chapter 5, General Features of Mollusks, describes the different features of each class of mollusk, complete with detailed, labeled images (including posterior, anterior, dorsal, and ventral views), that are large, clear, and easily understood.

Chapter 6, Texas Seashells, makes up the bulk of the text (295 pp.), sorted taxonomically by class, subclass, family, genus, and species. The taxonomic hierarchy is at the top of each page, making it easy to locate information while flipping through the text. A brief paragraph discusses each class and family. Each species description includes a photograph, the scientific name of the organism and its authorities, common name, distribution, size, brief physical description, habitat, remarks, and synonymous scientific names if applicable. This information is given in sections with bold headings for quick reference. For some species, sections on phenotypic variation and juvenile identification are provided.

Overall this appears to be a very complete overview of Texas Seashells and "must have" reference material for anyone interested in them. Again, this book is textbook size and is not meant to be a small field guide. It contains clear photographs of every species with a black background and is organized in a manner that makes it good quick reference material.

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J. Bot. Res. Inst. Texas 6(1): 130. 2012

WOODY SPECIES RICHNESS AND ABUNDANCE IN A TROPICAL SAVANNA OF NORTHERN GHANA

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ABSTRACT

The floristic composition and abundance of woody plants in a tropical savanna were studied at the Damongo Scarp of Northern Ghana. The purpose of the study was to identify the woody species and determine their abundance and densities in the study area. Ten nested square vegetation plots of 15 m × 15 m were used. Tree and shrub species were identified based on their physiognomic characteristics. A total of 693 trees belonging to 50 species, 41 genera and 20 families were recorded. Also 185 shrubs were identified belonging to 11 species, 10 genera and 8 families. Densities of 69.3 trees and 18.5 shrubs per 100 m^2 were established. The assessment revealed that the characteristics of the vegetation in the Scarp were generally similar to that of other guinea savanna areas. It has also revealed that the floristic composition (species richness) and abundance of woody species at different areas of the guinea savanna zone are unique.

Key Words: Woody plants, species abundance, Guinea savanna, Damongo Scarp, Ghana

RÉSUMÉ

La composition et l'abondance floristiques des plantes ligneuses dans une savane tropicale ont été étudiées dans l'escarpement de Damongo du Ghana nordique. Le but de l'étude était d'identifier les espèces ligneuses aussi que de déterminer leur abondance et densité dans le secteur d'étude. Dix parcelles nichées de terrain de végétation de prélèvement de 15 m × 15 m ont été employées. Les espèces d'arbres et d'arbustes ont été identifiées en se basant sur leurs caractéristiques physionomiques. Au total on enregistré un numéro de 693 arbres appartenant à 50 espèces, à 41 genres et à 20 familles. De la même manière, un total de 185 arbustes ont été identifiés, appartenant à 11 espèces, à 10 genres et à 8 familles de végétation. La densité a été établie à 69.3 arbres et 18.5 arbustes par 100 m^2. L'évaluation a indiqué que les caractéristiques de la végétation dans l'escarpement étaient généralement analogues à celles dans les autres secteurs de la savane de Guinée. Elle a également indiqué que la composition floristique (la richesse de l'espèce) et l'abondance de la variété ligneuse dans les différents secteurs de la zone de la savane de Guinée est unique.

INTRODUCTION

In Ghana, the savanna vegetation serves as a source of livelihood for about 30% of the population through the provision of economic resources such as *Vitellaria paradoxon* (Shea), *Parkia biglobosa* (Dawadawa), forage and fuelwood (Yaro 2008). Because of intensive farming, fuel wood harvesting and shortened fallow periods between cropping periods, savannas, especially those in Africa, are undergoing rapid changes in vegetation productivity, structure and composition (Jansen 1988; Lewis & Berry 1988). The guinea savanna zone of Ghana is estimated to cover about 60.77% of the country's total land mass and is the most dominant vegetation type (Anonymous 2002). Previous research carried out on the guinea savanna vegetation type of Ghana included Vigne (1936), Taylor (1952), Lawson et al. (1969), Hopkins (1979), Houssain and Hall (1996), Oteng-Yeboah (1996), Asase and Oteng-Yeboah (2007). All lacked an extensive documentation of diversity and abundance of plant species in the different savanna zones. However, a recent study by Asase et al. (2009) included abundance and distribution data of savanna woody species at the Sinsablingbini Forest Reserve, located 20 km from Tamale, the Northern Regional capital.

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The Damongo Scarp, unlike Mole National Park and Kenikeni forest, is the smallest reserve in the West Gonja District of Northern Region, Ghana. Some research has been carried out on the major reserves in the district, especially Mole National Park with monitoring programs initiated since the 1960s to the 1970s (Hall & Jenik 1968; Pegg 1969; Jamieson 1972).

Botanical assessments such as floristic composition, diversity and structure studies are vital in the framework of understanding the scope of plant diversity in various ecosystems (WCMC 1992; Addo-Fordjour et al. 2009). They are helpful for the estimation of sustainability of ecosystems since they play a major role in the conservation of plant species and ecosystem management (Tilman 1988; Ssegawa & Nkuutu 2006). Ecological data obtained in this regard are not only valuable for the application of sound management practices, they are also useful in identifying important elements of plant diversity, protecting threatened and economic species, and monitoring the state of vegetations (Tilman 1988; Ssegawa & Nkuutu 2006; Addo-Fordjour et al. 2009).

It is in this light that this research was carried out at the Damongo Scarp to ascertain its woody species' composition and density. Such information is urgently needed to serve as baseline data for management plans that aim at ensuring conservation and sustainable use of savanna vegetation. Specific objectives of this study were: (i) to determine the tree species richness and abundance of the scarp; (ii) to determine the shrub species richness and abundance; and (iii) to determine the regeneration status of trees at the scarp.

STUDY AREA

The study was carried out at the Damongo Scarp (39.36 km^2) in the West Gonja District of Northern Region. It is located north of Damongo (Fig. 1) and lies between longitude 1°5' and 2°58'W and latitude 8°32' and 10°2'N. It shares boundaries in the south with Central Gonja District, Bole and Sawla-Tuna-Kalba Districts in the West, Wa East District in the North West, West Mamprusi in the North, and Tolon-Kumbungu District in the East (WGDA 2008). The vegetation is categorized as guinea savanna (Dickson & Benneh 1988). The scarp has high temperatures with the maximum occurring in the dry season. The mean monthly temperature is 27° C. Rainfall is unimodal with an average annual precipitation of about 1144 mm.

METHODS

A total of 10 nested square sampling plots were laid. The first square plot of area 225 m^2 was laid at random and the subsequent plots laid 50 m away from each other. Trees with diameter at breast height (DBH) of 10 cm and above were recorded within the 225 m^2 plots. Smaller squared plots of 100 m^2 were located in the larger plots for the survey of young trees above a height of 1.30 m and below a DBH of 10 cm. Smaller squared plots of 25 m^2 were further located within the 100 m^2 plots for regenerating plants below 30 cm diameter. All individuals in these regeneration plots and subplots were counted by species.

All species of woody plants found rooted within each plot were identified and their individual plants counted. The identification of tree and shrub species was based on their physiognomic characteristics and later confirmed using relevant literature (Hutchinson & Dalziel 1957–1972; Arbonnier 2004; Hawthorne & Jongkind 2006), and by comparison with already identified specimens at the University for Development Studies Herbarium. All botanical nomenclature in this paper follows IPNI (2008).

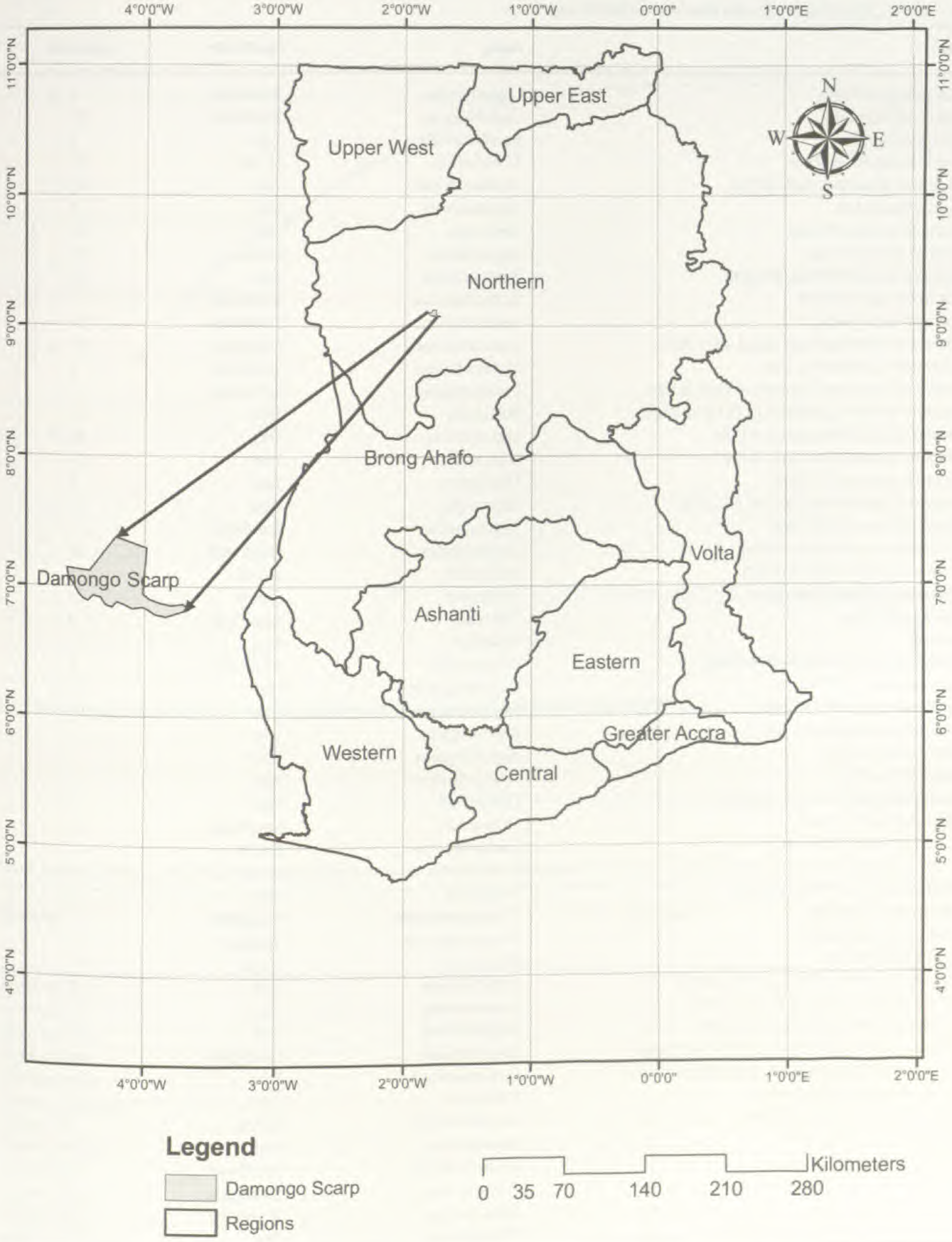
RESULTS

General Findings

A total of 61 woody species (trees and shrubs) belonging to 51 genera and 21 families were identified in the Damongo Scarp. Fifty (50) tree species belonging to 17 families were identified (Table 1) while 11 shrub species belonging to 8 families were recorded. About 36% of woody species were of the family Leguminosae.

The woody species accumulation, which is the cumulative number of species recorded as a measure of the sampling effort, shows that the majority of woody plants in the scarp were sampled during the study as seen on the curve (Fig. 2) as it reaches the asymptote.

Tree species richness and abundance.—A total of 693 individual trees belonging to 20 plant families, 41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Damongo Scarp
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Ashanti
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Greater Accra
Western
Central
Legend
Damongo Scarp
Regions
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Kilometers

Fig. 1. Map of Ghana indicating the Damongo Scarp.

genera and 50 species were recorded. About 85% (Table 1) of tree species genera consisted of only one species. Genera with two or more species were *Acacia* (2 species), *Combretum* (3 species), *Lannea* (2 species), *Lophira* (2 species), *Strychnos* (2 species) and *Terminalia* (2 species). The most species rich families were Leguminosae (40.8%), Combretaceae (12.1%), Meliaceae (9.9%) and Sapotaceae (7.9%), as illustrated in Table 2.

TABLE 1. Woody species, their families and abundances in the Damongo Scarp.

Species	Family	Growth form	Abundance
Acacia dudgeon Craib.	Leguminosae	Small tree	7
Acacia hockii De Wild.	Leguminosae	Small tree	20
Adansonia digitata L.	Bombacaceae	Tree	9
Annona senegalensis Pers.	Annonaceae	Shrub	24
Anogeissus leiocarpus Guill. & Perr.	Combretaceae	Tree	29
Afzelia africana Sm.	Leguminosae	Tree	4
Azadirachta indica A. Juss.	Meliaceae	Tree	29
Bauhinia rufescens Lam.	Leguminosae	Shrub	10
Bombax costatum Pellegr. & Vuillet	Bombacaceae	Tree	22
Bridelia ferruginea Benth.	Euphorbiaceae	Small tree	7
Burkea africana Hook.	Leguminosae	Small tree	52
Combretum adenogonium Steud. ex A. Rich	Combretaceae	Small tree	31
Combretum comosum G. Don	Combretaceae	Small tree	3
Combretum nigricans Leprieur ex Guill. & Perr.	Combretaceae	Small tree	7
Crossopteryx febrifuga (Afzel. ex G. Don.) Benth.	Rubiaceae	Tree	12
Daniella oliveri (Rolfe) Hutch. & Dalz.	Leguminosae	Tree	40
Detarium microcarpum Guill. & Perr.	Leguminosae	Tree	50
Diospyros gabunensis Gürke	Ebenaceae	Tree	6
Diospyros mespiliformis Hochst. ex. A. DC	Ebenaceae	Tree	13
Entadra Africana Guill & Perr.	Leguminosae	Small tree	7
Erythrophleum africanum Harms	Leguminosae	Small tree	30
Gardenia aqualla Stapf. & Hutch.	Rubiaceae	Shrub	4
Gardenia ternifolia Schumach.	Rubiaceae	Shrub	21
Grewia mollis Juss.	Tiliaceae	Small tree	8
Ficus spp.	Moraceae	Tree	13
Hexalobus monopetalus Engl. & Diels.	Annonaceae	Small tree	3
Hymenocardia acida Tul.	Euphorbiaceae	Tree	10
Isoberlinia doka Craib. & Stapf.	Leguminosae	Tree	20
Kigelia africana (Lam.) Benth.	Bignoniaceae	Tree	3
Lannea acida A. Rich.	Anacardiaceae	Tree	7
Lannea barteri Engl.	Anacardiaceae	Tree	5
Lophira alata Banks ex. C.F. Gaertn.	Ochnaceae	Tree	4
Lophira lanceolata Tiegh.	Ochnaceae	Small tree	23
Macaranga barteri Müll. Arg.	Euphorbiaceae	Shrub	2
Maytenus senegalensis (Lam.) Exell.	Celastraceae	Shrub	6
Mitragyna inermis (Willd.) Kuntze	Rubiaceae	Tree	3
Monotes kerstingii Gilg.	Dipterocarpaceae	Small tree	2
Nauclea diderrichii Merr.	Rubiaceae	Shrub	3
Nauclea latifolia Sm.	Rubiaceae	Shrub	17
Ostryoderris stuhlmannii Dunn ex Baker f.	Leguminosae	Tree	6
Parkia biglobosa (Jacq.) R. Br. ex G. Don	Leguminosae	Tree	17
Parinari curatellifolia Planch. ex Benth.	Leguminosae	Tree	16
Pericopsis laxiflora (Benth. ex. Baker) Meeuwen	Leguminosae	Small tree	4
Piliostigma thonningii (Schumach.) Milne-Redh.	Leguminosae	Tree	14
Pseudocedrela kotschyi Harms	Meliaceae	Tree	16
Pteleopsis suberosa Engl. & Diels	Combretaceae	Shrub	9
Pterocarpus erinaceus Lam.	Leguminosae	Tree	15
Quassia undulata D. Dietr.	Simaroubaceae	Small tree	14
Securidaca longipenduculata Fresen.	Polygalaceae	Small tree	9
Sterculia setigera Delile	Sterculiaceae	Small tree	9
Stereospermum kunthianum Cham.	Bignoniaceae	Tree	13
Strychnos spinosa Lam.	Loganiaceae	Small tree	4
Strychnos innocua Delile	Loganiaceae	Small tree	14
Tamarindus indica L.	Leguminosae	Tree	4
Terminalia avicennioides Guill. & Perr.	Combretaceae	Small tree	41
Terminalia macroptera Guill. & Perr.	Combretaceae	Tree	8
Trichilia emetica Vahl.	Meliaceae	Tree	31
Vitellaria paradoxa C.F. Gaertn.	Sapotaceae	Tree	61
Vitex doniana Sweet	Lamiaceae	Small tree	1
Ximenia americana L.	Olacaceae	Shrub	3
Ziziphus mauritiana Lam.	Rhamnaceae	Shrub	3

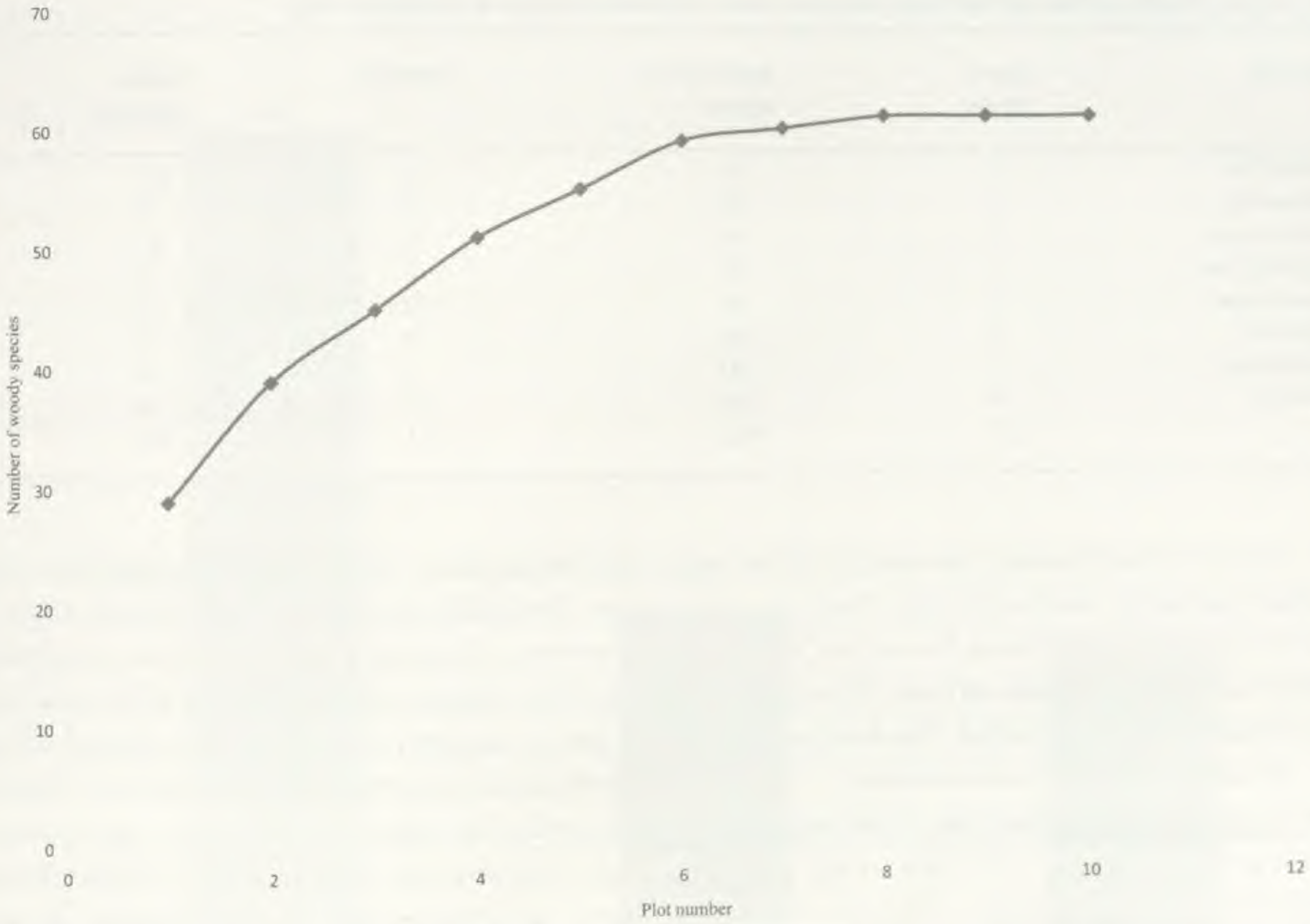

FIG. 2. Woody species accumulation curve indicating the sampling effort in the Damongo Scarp sample.

TABLE 2. Families of trees identified with their respective species richness and relative abundances in the Damongo Scarp.

Tree Family	Species Richness	Relative Species Richness	Abundance	Relative Abundance
Anacardiaceae	2	4	12	1.6
Annonaceae	1	2	3	0.4
Bignonaaceae	2	4	16	2.1
Bombacaceae	2	4	46	6
Combretaceae	6	12	93	12.1
Dipterocarpaceae	1	2	2	0.3
Ebenaceae	2	4	19	2.5
Euphorbiaceae	2	4	17	2.2
Lamiaceae	1	2	1	0.1
Leguminosae	16	32	313	40.8
Loganiaceae	2	4	18	2.3
Meliaceae	3	6	76	9.9
Moraceae	1	2	4	0.5
Ochnaceae	2	4	27	3.5
Polygalaceae	1	2	9	1.2
Rubiaceae	2	4	15	2
Sapotaceae	1	2	61	7.9
Simaroubaceae	1	2	14	1.8
Sterculiaceae	1	2	9	1.2
Tiliaceae	1	2	13	1.7
	50	100	768	100.1

TABLE 3. Families of shrubs identified with their respective species richness and relative abundances in the Damongo Scarp.

Shrub Family	Species Richness	Relative Species Richness	Abundance	Relative Abundance
Annonaceae	1	9.1	29	26.1
Celastraceae	1	9.1	6	5.4
Combretaceae	1	9.1	9	8.1
Euphorbiaceae	1	9.1	2	1.8
Leguminosae	1	9.1	10	9
Olacaceae	1	9.1	3	2.7
Rhamnaceae	1	9.1	3	2.7
Rubiaceae	4	36.4	49	44
	11	100.1	111	99.8

The five most abundant tree species in the scarp, contributing about 32% of total individual trees, were *Vitellaria paradoxa, Burkea africana, Detarium microcarpum, Terminalia avicennioides,* and *Daniella oliveri,* in decreasing order of abundance. In contrast, the least abundant were *Mitragyna inermis, Hexalobus monopelalus, Combretum collinum, Kigelia africana, Monotes kerstingii,* and *Vitex doniana,* representing 2% of the total number of individual trees recorded. The density of woody tree species was determined to be 69.3 trees per 100 m^2.

Shrub species richness and abundance.—A total of 185 individual shrubs belonging to 8 families, 10 genera and 11 species was recorded. The shrub family Rubiaceae recorded the highest number with 4 species, representing 36% (Table 3). The remaining plant families—Annonaceae, Celastraceae, Combretaceae, Euphorbiaceae, Leguminosae, Olacaceae, and Rhamnaceae—all recorded just one species each. The most abundant shrub species in the reserve were *Annona senegalensis, Gardenia aqualla,* and *Nauclea latifolia* contributing about 60% of the total number of shrubs identified. In contrast, the least abundant species were *Ximenia americana, Ziziphus mauritiana, Nauclea diderrichii,* and *Macaranga barteri,* representing about 10% of the total species recorded. The density of woody shrub species calculated per 100 m^2 was 18.5.

Regeneration status of trees in Damongo Scarp.—The regeneration study revealed a total of 39 tree species in all sampling sites, representing 18 families. The diameter class 0–4.99 cm (56.6%) was highest with 392 individuals, followed by the diameter class 5–9.99 cm (22.9%) with 159 trees, and lastly, big trees 10 cm and above (20.50%) had 142 trees. This indicates that the majority of individual trees were regenerating trees (56.6%) as illustrated in Figure 3.

DISCUSSION

Trees and shrubs which are widely distributed in the area constitute an integral component of the Damongo Scarp (Fig. 4). The species identified at the Damongo Scarp are similar to those reported in other guinea savanna areas of Ghana (Lawson et al. 1969; Hall 1976; Schitt & Adu-Nsiah 1993; Houssain & Hall 1996; Oteng-Yeboah 1996; Asase & Oteng Yeboah 2007; Asase et al. 2009). However, *Belanities aegyptiaca,* a common woody species recorded in surrounding areas of the guinea savanna, was not recorded in this study. Some species like *Rourea coccinea, Dalbergia afzeliana,* and *Hoslundia opposita,* recorded by Asase et al. (2009) but not in other savanna areas, were also not found in this study.

In a study of woody plant composition in a tropical savanna in northern Ghana, Asase et al. (2009) noted 43 species belonging to 13 families. Bright (2007), in a study of gradation in density of woody species around Lake Taakor in Tolon-Kumbungu in northern Ghana, recorded 47 species belonging to 22 families. Also Yahaya (2007) recorded 46 tree species belonging to 20 families. Schitt and Adu-Nsiah (1993) recorded a very high number (148) of tree species at the Mole National Park, Damongo (MNP), while Houssain and Hall (1996) reported a lower number (90) of tree species in the same MNP. Though most of the species recorded in this current study were recorded in all the above studies, a few different species (22%) were also recorded. This indicates that floristic composition of savanna is variable, even over relatively homogenous areas (Hopkins 1979; Lawson 1985).

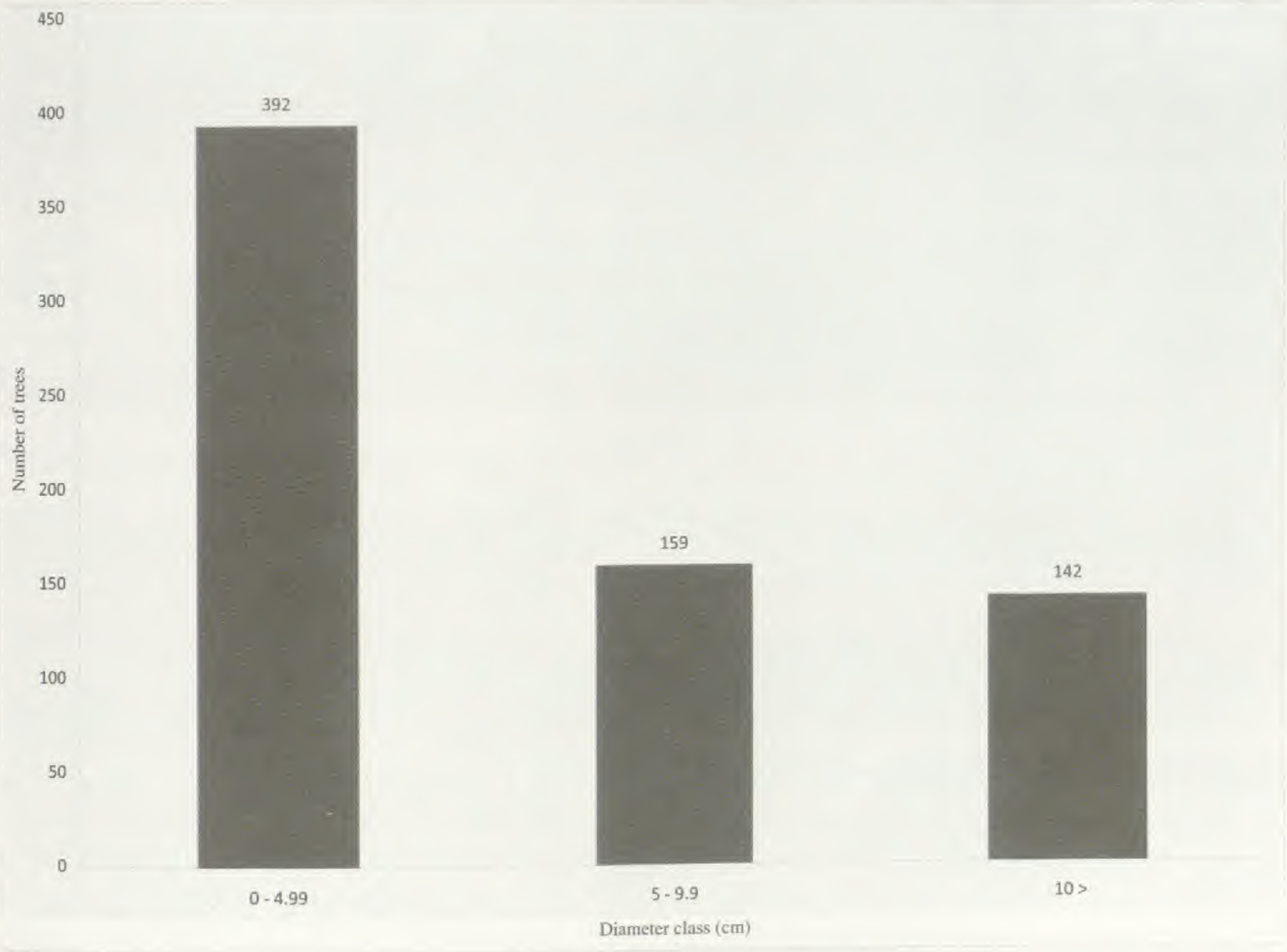

Fig. 3. Distribution of trees in the various diameter classes in the Damongo Scarp sample.

The high species richness and abundance of tree families such as Leguminosae (formerly Fabaceae) and Combretaceae in the guinea savanna have been noted elsewhere (Hopkins 1979; Asase & Oteng-Yeboah 2007; Asase et al. 2009). In a study of three traditional groves in northern Ghana, Oteng-Yeboah (1996) also reported the predominance of the family Leguminosae (Caesalpinaceae, Papilionaceae, and Mimosaceae) and Combretaceae in the different groves which is similar to the results of this study. The families Leguminosae (Mimosaceae and Caesalpinaceae) and Combretaceae, found to be dominant in this study, were also common among the dominant families reported by Bright (2007) and Yahaya (2007). However, Meliaceae, though reported as dominant in this study, was not a dominant family in the other studies. Hence, the same families may run through the various guinea savanna zones of northern Ghana but some may be dominant whereas others may not. Interestingly, some families (Sapotaceae and Bombacaceae) with few species recorded very high abundances; it follows that not all the families with many species are abundant (Asase et al. 2009) in the scarp.

It was observed that important economic trees such as *Vitellaria paradoxa* (Shea) and *Parkia biglobosa* (Dawadawa) were among the dominant species in the reserve, which conforms with the suggestion of Yaro (2008) that savanna vegetation of Ghana provides ecological conditions for economic trees such as Shea and Dawadawa. Apart from *Azadirachta indica* and *Acacia* spp., which were exotic savanna species, all the other species observed were native savanna species. The savanna vegetation is generally under threat from bushfires (Abatania &Albert 1993; Gordon & Ametekpor 1999) and grazing animals (Winter 1991; Smith & Franks 2000) which promotes the spread of weeds. Four woody species (*Afzelia Africana, Lophira alata, Nauclea diderrichii*, and *Vitellaria paradoxa*) are stated as vulnerable in the IUCN red list of threatened species (IUCN 2012).

The DBH class 0–4.99 cm recorded the highest percentage (56.6%) of the total individual tree species, indicating that most of the plant species were in the regenerating stage. Although Asase et al. (2009) reported

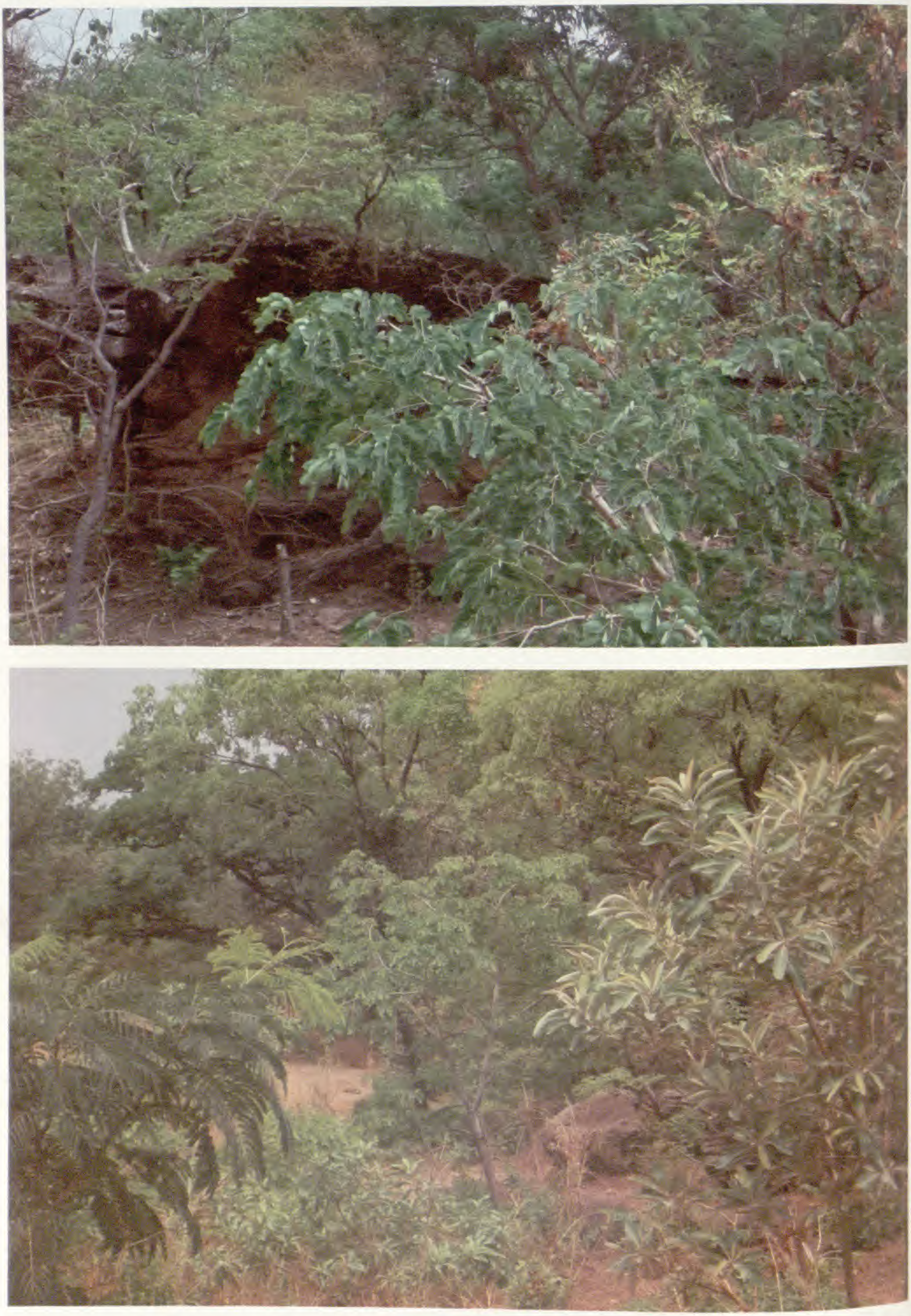

Fig. 4. Photographs of two sample plots showing the trees and shrubs on the Damongo Scarp.

big trees as being dominant in their study, this result is an indication of a secondary forest defined by Chokkalingam and DeJong (2001) as forests regenerating largely through natural processes after significant human and/or natural disturbance of the original forest vegetation.

The shrub species identified on the scarp are among the species that have been reported in guinea savanna areas of Ghana (Lawson et al 1969; Hall 1976; Schitt & Adu-Nsiah 1993; Oteng-Yeboah 1996; Asase & Oteng Yeboah 2007; Yahaya 2007; Asase et al. 2009). A total of 11 shrub species belonging to 8 different families were recorded in the scarp. Schitt and Adu-Nsiah (1993) reported 61 shrub species while Asase et al. (2009) recorded 19 species belonging to 8 different plant families elsewhere in guinea savanna of Northern Ghana and Yahaya (2007) recorded 15 species belonging to 11 families.

The results suggest that generally guinea savanna zones of Ghana are less rich in savanna shrubs. Five families—Euphorbiaceae, Annonaceae, Celastraceae, Rubiaceae, and Fabaceae (now Leguminosae), reported by Asase et al. (2009)—were also found in this study, with Rubiaceae being the species rich family. Yahaya (2007) recorded 15 shrub species belonging to 11 families, with Rubiaceae being the species rich family. Similarly Bright (2007) identified 8 shrub species belonging to 5 plant families, with Rubiaceae the dominant family. Comparatively the shrub species recorded in this study was either higher or lower than the above mentioned studies, however, Rubiaceae was commonly the dominant family throughout the studies. This indicates that Rubiaceae may be the family with the largest number of shrub species in the guinea savanna zone of Northern Ghana. The abundance of two species recorded, *Annona senegalensis* and *Gardenia aqualla* in the reserve, confirms their frequent occurrence in the study area, as also reported previously by Schitt and Adu-Nsiah (1993).

Densities of 69.3 trees per 100 m^2 and 18.5 shrubs per 100 m^2 were recorded in the scarp. Tom-Dery and Schroeder (2011) stated this method of estimating density as being systematically incorrect, but used it to compare survey results with those of other authors in Ghana, and it is herein used for such comparative purposes. Yahaya (2007) recorded a density of 39 trees per 100 m^2 and 8 shrubs per 100 m^2 similar to Asase et al. (2009) who also recorded a density of 39 trees per 100 m^2 and 15.4 shrubs per 100 m^2. The higher density of trees than shrubs recorded in this study compared to the two previous studies, suggests that densities of trees are far higher than shrubs in guinea savanna areas which implies that more tree species are widely distributed in the savanna areas than shrubs. This further implies that savanna areas are richer in trees than shrubs. This finding confirms the report of Cole (1986) and Stott (1991) that in savannas, tree densities are higher.

To conclude, the study is the first work on the woody species abundance and species richness in the Damongo Scarp. The assessment has revealed that the characteristics of the vegetation in the scarp were generally similar to those of other guinea savanna areas. It has also revealed that the floristic composition (species richness) and abundance of woody species in different areas of the guinea savanna zone are unique. It is therefore vital to study the diversity of plants found in the different areas of the guinea savanna zone of Ghana to effectively conserve the botanical resources of the different areas, especially unique land masses such as the Damongo Scarp.

ACKNOWLEDGMENTS

We wish to sincerely thank James Braimah of AROCHA GH for all the support during the field work. We are also grateful to Mrs. Elena Hietsch for translating the abstract and not forgetting B.N. Baatuuwei for proof reading this script. And we thank the journal reviewers Michael MacRoberts and an anonymous colleague for their detailed and critical reviews.

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BOOK REVIEWS

Jim Kimmel. Photographs by Jerry Touchstone Kimmel. Foreword by Andrew Sansom. 2011. **Exploring the Brazos River From Beginning to End.** (ISBN: 978-1-60344-432-3, pbk.). Texas A&M University Press, John H. Lindsey Bldg., Lewis St., 4354 TAMU, College Station, Texas 77843-4354, U.S.A. (**Orders:** www.tamupress.com, 800-826-8911). $24.95, 192 pp., 72 color photos, 7 maps, 8.5" × 10".

The Brazos River crosses Texas from the northwest to the Gulf of Mexico. Along the way the longest river in Texas travels through six of the ten major ecoregions regions of the state. The author does a marvelous job of guiding us along the entire route of the Brazos. In words and photographs he introduces us to the plants, animals, landforms, rivers, and geology of Texas.

Starting in the dry High Plains in New Mexico the river and the author follow a winding pathway across the High Plains, Rolling Plains, Cross Timbers, and Prairies. Both then move on to the Blackland Prairie, Post Oak Savannah, and Gulf Prairie and Marshes regions. In each section, the author points out key features of the river and the landscape. He thoughtfully lists state parks, historical landmarks, and places to visit.

Texas is a large and diverse state and it is difficult to grasp this diversity easily. By using this single river the Kimmels provide the reader with a cross section of the state. Sections of the book deal with the science of rivers and water flow, plant and animal ecology, and key agricultural activities. I especially appreciated the sections titled "Where to Experience the Land and River." Within each region the author notes these points of interest and invites the reader to travel to these sites.

This book is a guide for travelers, an introduction to a variety of natural sciences, and a history of the state as it expanded from coastal settlements to the high plains. The book is a fun read and is a welcome companion for anyone exploring the various sections of the Brazos Basin.

—Richard Lankow, Ph.D., Volunteer,
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Gil Nelson. 2011. **Botanical Keys to Florida's Trees, Shrubs, and Woody Vines: A Guide to Field Identification.** (ISBN: 978-1-56164-499-5, pbk.). Pineapple Press, Inc., P.O. Box 3889, Sarasota, Florida 34230, U.S.A. (**Orders:** www.pineapplepress.com). $19.95, 208 pp., 2 b/w plates, 6" × 9".

Morphological characteristics used to identify species are defined in a 9-page glossary along with 2 pages of line drawings for leaves. There are no photographs included, which limits the use of this book as a standalone publication for the identification of trees, shrubs, and woody vines in Florida. Indeed, the flyer suggests that this book should be a companion to *The Trees of Florida* and *The Shrubs and Woody Vines of Florida*. The book is designed primarily for field use and the handheld size and light weight will facilitate carrying the book in the field. The dichotomous keys are constructed as numbered couplets, usually less than 14 leads and based mostly on leaf morphology. Most of the key characteristics are based on easily seen features with emphasis on traits observable throughout the year. There are two sets of keys: one a master key to major groups of woody plants and another to 128 families. The families are arranged alphabetically by scientific name, followed by the author's name but without regard to phylogeny or higher ranks of classification. Choice of family names is based on the Angiosperm Phylogeny Group classification.

Two paginated indices, one for genus and another for common names, facilitate location of names within the text. Native and non-native species are included and endangered, threatened, or invasive species are designated by symbols. Taxa listed include habitat descriptions and county distribution patterns. Persons with a special need to identify Florida plants will find this book useful.

—Harold W. Keller, Research Associate,
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COMPOSICIÓN FLORÍSTICA Y ECOLOGÍA DEL MATORRAL SUBMONTANO DE ROSÁCEAS DE LA SIERRA DE ZAPALINAMÉ, COAHUILA, MÉXICO

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RESUMEN

La Sierra de Zapalinamé es una estribación de la Sierra Madre Oriental en la transición con el Desierto Chihuahuense, decretada en 1996 como Zona Sujeta a Conservación Ecológica. El matorral submontano de rosáceas se localiza en esta sierra en las laderas bajas con exposición noroeste, en transición con matorral desértico micrófilo y bosque de encino. Con la finalidad de conocer la estructura, composición florística y aspectos ecológicos del matorral submontano de rosáceas, se establecieron 23 sitios de muestreo de 75 m^2, en donde se evaluó la densidad y cobertura de especies leñosas, mientras que las especies herbáceas se cuantificaron en parcelas rectangulares de 2 m^2. Con los atributos de la vegetación se calculó el valor de importancia relativa de leñosas y herbáceas. Se realizaron colectas botánicas. La flora vascular se integra por 49 familias, 144 géneros y 223 especies, incluyendo taxa infraespecíficos, las familias con mayor riqueza de especies son: Asteraceae (48 especies), Poaceae (36), Fabaceae (15), Lamiaceae (9) y Cactaceae (9). Las especies arbustivas importantes en el estrato superior (≥1m) son: *Purshia plicata* (2,041 ind/ha), *Malacomeles denticulata* (1,536 ind/ha) y *Lindleya mespiloides* (1,067 ind/ha); en el estrato arbustivo inferior (≤ 1 m) dominan *Mimosa biuncifera* (2,087 ind/ha), *Chrysactinia mexicana* (1,067 ind/ha), *Gymnosperma glutinosum* (1,119 ind/ha) y *Berberis trifoliolata* (568 ind/ha). Las especies herbáceas más abundantes son: *Dyssodia papposa*, *Muhlenbergia setifolia*, *Bouteloua curtipendula*, *B. hirsuta* y *Loeselia coerulea*. El estrato arbustivo presenta una diversidad florística de 2.76 nats y una equitatividad de 68.56%, la riqueza y la diversidad se incrementa con la altitud. El matorral se desarrolla en un intervalo altitudinal de 1,770 a 2,200 m, la precipitación media anual es de 450 a 550 mm y la temperatura media anual oscila entre 12 y 16°C. La urbanización y los incendios son los principales factores que amenazan la permanencia de esta comunidad.

Palabras clave: densidad de arbustos, diversidad de especies, matorral xerófilo, Rosaceae

ABSTRACT

The Sierra de Zapalinamé is a branch of the Sierra Madre Oriental located in the transition zone to the Chihuahuan Desert. It was enacted as a natural protected area in 1996. The piedmont scrub is located on the northwest lower slopes of the sierra, in a transition zone between the desert scrub and the oak forest. In order to know its structure, floristic composition and ecological aspects, 23 sampling sites of 75 m^2 were established, where the density and cover of woody species were evaluated; the herbs were quantified in plots of 2 m^2. Samples of all the plant species were collected and identified. With the vegetation attributes was calculated the relative importance value for woody and herbaceous species. The vascular flora comprises 49 families, 144 genera and 223 species, including infraspecific taxa, the largest families are Asteraceae (48 species), Poaceae (36), Fabaceae (15), Lamiaceae (9) and Cactaceae (9). The main shrub species in the upper layer (≥ 1m) are: *Purshia plicata* (2,041 ind/ha), *Malacomeles denticulata* (1,536 ind/ha) and *Lindleya mespiloides* (1,067 ind/ha). The lower layer (≤ 1m), includes: *Mimosa biuncifera* (2,087 ind/ha), *Chrysactinia mexicana* (1,067 ind/ha), *Gymnosperma glutinosum* (1,119 ind/ha), and *Berberis trifoliolata* (568 ind/ha). The most common herbaceous species are: *Dyssodia papposa*, *Muhlenbergia setifolia*, *Bouteloua curtipendula*, *B. hirsuta* and *Loeselia coerulea*. The scrub has a value diversity of 2.76 nats and an evenness of 68.56%, which increase with altitude. The scrub is developed on an altitudinal range of 1,770 to 2,200 m, the annual precipitation is 450–550 mm and the mean annual temperature ranges between 12 and 16°C. Urbanization and fires are the main factors affecting the piedmont scrub.

Key Words: diversity of species, Rosaceae, shrub density, xerophytic scrub

En México el matorral xerófilo ocupa el 40% del territorio, se distribuye en regiones con clima árido y semiárido (Rzedowski 1978) y, junto con los pastizales, tiene una riqueza de 6,000 especies de plantas vasculares, lo cual representa el 20% de la flora del país (Rzedowski 1991). Una variante de esta vegetación es el Matorral submontano (Rzedowski 1966), el cual también ha sido nombrado como "*piedmont scrub*" (Muller 1939), o chaparral (Pinkava 1980; Henrickson y Johnston 1983; Valdez y Aguilar 1983) y matorral esclerófilo perennifolio (Flores et al. 1999). El matorral submontano se distribuye a través de la Sierra Madre Oriental desde Coahuila hasta el centro-sur de México (Muller 1947; Rzedowski 1978; Valiente et al. 1998), en climas semiá-

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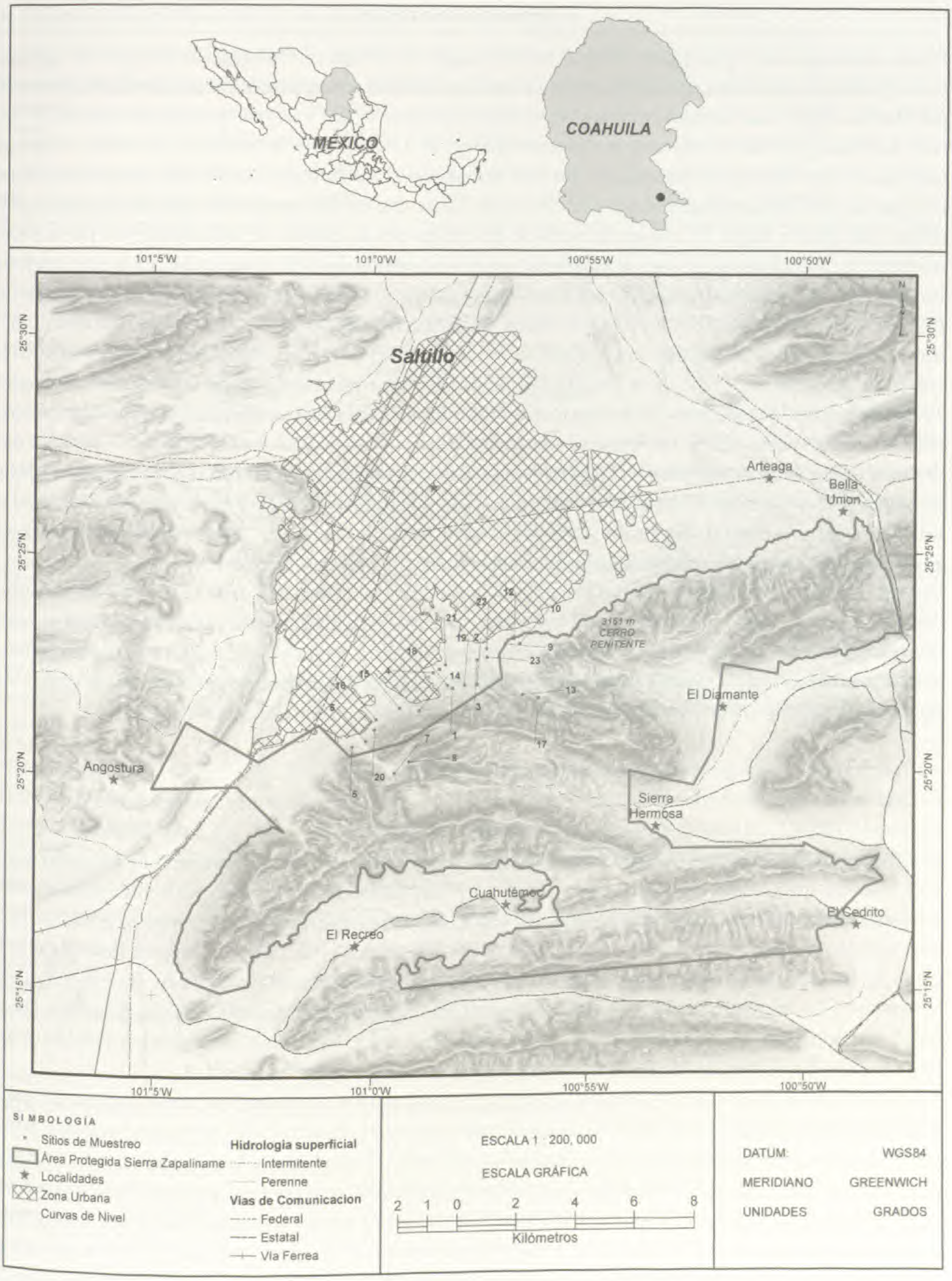
ridos y altitudes inferiores a los 2,000 m. Se trata de un matorral denso de hasta 3 m de alto, integrado por arbustos micrófilos e inermes (Rzedowski 1978). En el estado de Coahuila el matorral submontano representa el 5.14% de la superficie estatal (Anónimo 2001), es frecuente en altitudes superiores a los 1,800 m, en laderas bajas y cañones de los sistemas montañosos, en sitios con suelos someros, aunque su distribución se extiende hasta comunidades boscosas y en sus límites inferiores se mezcla con el matorral rosetófilo (Henrickson y Johnston 1983). Las especies dominantes pertenecen a los géneros: *Quercus*, *Rhus*, *Diospyros*, *Acacia* y *Calia*, además de especies de la familia Rosaceae.

Una variante de esta vegetación es el matorral denso inerme parvifolio de rosáceas (sensu Marroquín 1976; Arce y Marroquín 1985) o matorral submontano de rosáceas, el cual se distribuye en la Sierra de Zapalinamé entre 1,800 y 2,480 m de altitud en la ecotonía con el matorral desértico chihuahuense y los bosques de encino (Villarreal y Valdés 1992–93; Encina et al. 2007), donde representa el 2.86% (cerca de 1,820 ha) del macizo montañoso (Anónimo 1998). La Sierra de Zapalinamé se localiza en el sureste de Coahuila, es una estribación de la subprovincia fisiográfica de la Gran Sierra Plegada en el noreste de México, se ubica en la zona de transición con el Desierto Chihuahuense (Anónimo 1998) y es un área natural protegida, decretada en 1996 como Zona Sujeta a Conservación Ecológica por el gobierno del estado de Coahuila (Anónimo 1996). El matorral submontano de rosáceas se distribuye adyacente a la ciudad de Saltillo, por lo cual los incendios forestales, el cambio de uso del suelo y la recreación mal planificada han ocasionado que sea la comunidad vegetal más afectada, lo que ha contribuido a reducir su superficie y modificar la composición de especies. Arce y Marroquín (1985) consideran que la intensidad de disturbio está en relación directa con la cercanía a la zona urbana. El objetivo del presente estudio es determinar la composición, estructura y aspectos ecológicos del matorral submontano de rosáceas de la Sierra de Zapalinamé.

ÁREA DE ESTUDIO

La Sierra de Zapalinamé forma parte de los municipios de Saltillo y Arteaga y se ubica aledaña a la ciudad de Saltillo, entre los 25°15'00" - 25°25'58.35" latitud norte y los 100°47'14.5" - 101°05'3.8" longitud oeste (Fig. 1). Al norte colinda con la ciudad de Saltillo, al este con la carretera 57 (México - Piedras Negras), al oeste con la carretera 54 (Saltillo - Zacatecas) y al sur está limitada por la coordenada de latitud 25°15'. La región pertenece a la subprovincia fisiográfica de la Gran Sierra Plegada; el macizo incluye valles, planicies y montañas. La orientación de los pliegues transversales es de este a oeste, las altitudes van desde 1,590 m en el pie de monte hasta los 3,140 m en el cerro El Penitente, su mayor elevación, y con valles intermontanos a 2,200 m. La sierra está disectada por cañones, con pendientes abruptas y topografía accidentada. Las rocas que afloran en el área son sedimentarias marinas del Jurásico y Cretácico, las calizas cubren 43% del área, las areniscas y los conglomerados 17%. Los suelos aluviales ocupan casi 30% del área, son de profundidad variable y constituyen planicies con abanicos al pie del macizo, en los valles son profundos y con buen drenaje. Abundan los suelos de tipo litosol y rendzina, ambos constituyen casi 80% de la superficie del área; los litosoles son superficiales y sobreyacen a la roca o caliche cementado, representan 49% del área; los rendzina son pedregosos y someros, con una capa superficial de humus, sobre roca caliza o material rico en cal en el pie de monte y valles y representan 29%. En menor proporción se localizan los xerosoles cálcicos y feozem calcárico (Anónimo 1983, 1998).

El clima predominante en la región es seco BSkw y en las partes altas de la sierra el clima es templado C(W_0) (Anónimo 1998). La caseta meteorológica más cercana se ubica en Buenavista, Saltillo, Coah. (23°38'N, 103°38'W, a 1588 m s.n.m.), donde se registra una temperatura media anual de 16.9° C, la precipitación media anual de 498 mm, valores que se consideran próximos a los correspondientes a las partes bajas de la Sierra de Zapalinamé; las lluvias son de tipo convectivo, coinciden con los meses calientes del año. Arce y Marroquín (1985) describen 11 comunidades vegetales para el macizo montañoso, mencionan que la cubierta vegetal en áreas con exposición sur presenta matorral rosetófilo, mientras que en las partes altas se presentan bosques de pino y oyamel, en los cañones se localizan bosques de encino y en las laderas bajas de exposición norte y oeste se presenta el matorral denso inerme parvifolio de rosáceas. Los tipos de vegetación mejor representados son el bosque de pino que ocupa 14.09% de la superficie total del área protegida, el bosque de piñonero 12.54% y el bosque de piñonero con matorral xerófilo 9.55% (Anónimo 1998).


MÉXICO
COAHUILA
101°5'W
101°0'W
100°55'W
100°50'W
25°30'N
25°25'N
25°20'N
25°15'N
N
Saltillo
Arteaga
Bella Unión
3161 m CERRO PENITENTE
El Diamante
Angostura
Sierra Hermosa
Cuahutémoc
El Recreo
El Cedrito
1
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23
SIMBOLOGÍA
Sitios de Muestreo
Área Protegida Sierra Zapaliname
Localidades
Zona Urbana
Curvas de Nivel
Hidrologia superficial
Intermitente
Perenne
Vías de Comunicacion
Federal
Estatal
Vía Ferrea
ESCALA 1 : 200, 000
ESCALA GRÁFICA
2 1 0 2 4 6 8
Kilómetros
DATUM: WGS84
MERIDIANO GREENWICH
UNIDADES GRADOS

Fig. 1. Ubicación del área de estudio: Sierra de Zapalinamé y localización de los sitios de muestreo.

MATERIALES Y MÉTODOS

Para la medición de la vegetación se utilizó el método de parcela (Mueller-Dombois y Ellenberg 1974). Se levantaron 23 sitios de muestreo, su establecimiento se realizó mediante la compensación por pendiente propuesto por Medina (1983). Las especies arbustivas se evaluaron en parcelas de 75 m^2 mientras que las especies del estrato herbáceo se midieron en tres parcelas rectangulares de 2 m^2 por sitio de muestreo, en ambos estratos se tomó la altura y cobertura de las especies. En cada sitio se registró la altitud y coordenadas geográficas con un receptor de GPS, profundidad de suelo con barrena de 1.5 m, exposición topográfica (con una brújula) y pendiente (con pistola Haga). La textura del suelo se determinó con el método del hidrómetro y el pH se midió mediante la concentración de iones de hidrógeno en una suspensión de suelo, agua o solución de sal a través de un electrodo de vidrio. Los valores de precipitación, temperatura y tipo de suelo se tomaron del Sistema de Información Geográfica para el Manejo y Planeación por Microcuencas (SIGMAPLAN-Coahuila sureste) (Anónimo 2003). Se recolectaron muestras botánicas las cuales se herborizaron, identificaron e incluyeron en la colección del herbario ANSM de la Universidad Autónoma Agraria Antonio Narro (Holmgren y Holmgren 1990). Para todas las especies se calcularon los atributos básicos de la vegetación y con la suma de los valores relativos se obtuvo el valor de importancia relativa por especie (Krebs 1999). La diversidad se cuantificó mediante el índice de Shannon-Wiener (Ludwig y Reynolds 1988; Magurran 1988) con la ecuación: $H' = -\Sigma pi\ (\ln pi)$, donde *pi* es la densidad relativa de las especies en cada sitio de muestreo. Para el cálculo de la diversidad se utilizó el logaritmo natural (Magurran 1988), por lo que el índice se expresa en "nats" (Pielou 1969). La riqueza de especies es medida y analizada en términos del número de especies. Se calculó la equitatividad de especies (E), la cual es una medida de la uniformidad en la abundancia relativa de éstas en cada parcela, calculada con base a Pielou (1966): $E = H'/H'_{max.} = H'/\ln R$, donde H' es la diversidad actual de la comunidad, $H'_{max.}$ es la diversidad máxima potencial y R es riqueza o número de especies. Se realizó un análisis de regresión lineal simple para determinar la riqueza y diversidad de especies a través del gradiente de altitud, para lo cual se utilizaron los índices de diversidad y el número de especies por sitio así como los valores de altitud.

RESULTADOS

La flora vascular se integra por 49 familias, 144 géneros y 223 especies, incluyendo taxa infraespecíficos, de los cuales el 95.96% (214 taxa) pertenecen a la división Magnoliophyta, el 3.14% (7) a Pteridophyta y el resto (0.90%) a Pinophyta (Tabla 1); las dicotiledóneas aportan el 73.09% (163 taxa) a la riqueza florística del matorral, mientras que las monocotiledóneas el 22.86% (51). La distribución de los taxa por familia presenta diferencias marcadas, ya que las 10 familias más ricas (con seis o más taxa) agrupan en conjunto el 67.26% de la flora registrada y las 39 familias restantes (79.59%) contribuyen con el 32.73% de la riqueza. Asteraceae es la principal familia con 48 taxa, le siguen Poaceae (36), Fabaceae (15), Lamiaceae y Cactaceae (9), Euphorbiaceae y Rosaceae (7). Los géneros con mayor número de taxa son: *Salvia* (6), *Ageratina* (6), *Aristida*, *Bouteloua*, *Dalea*, *Muhlenbergia* y *Quercus* (c/u con 5) (ver listado florístico en Anexo 1). Las especies arbustivas más frecuentes son: *Lindleya mespiloides*, *Malacomeles denticulata*, *Mimosa biuncifera* y *Purshia plicata*.

En el Tabla 2 se compara la composición (especies más frecuentes) y la distribución altitudinal del matorral submontano de rosáceas de la Sierra de Zapalinamé con la del chaparral y la vegetación esclerófila perennifolia en otras localidades en México. La semejanza con estas comunidades se hace evidente, ya que todas se ubican por arriba de los 1,600 m de altitud y se componen principalmente por especies de las familias Rosaceae y Fagaceae; en todas ellas prevalecen: *Lindleya mespiloides*, *Malacomeles denticulata*, *Rhus virens*, *Garrya ovata* y *Arbutus xalapensis*, así como especies de los géneros *Quercus* y *Cercocarpus*. La mayor similitud se presenta entre localidades más cercanas al área estudiada (Coahuila y Nuevo León) con las cuales comparte el 75% de las especies, mientras que con Durango y Puebla se comparten el 62% y el 50% respectivamente.

La comunidad está dominada por elementos arbustivos, inermes, micrófilos y esclerófilos, aunque también son frecuentes plantas espinosas. Las formas de vida arbóreas están poco representadas y se distribuyen en las partes más altas, así como en cañones y arroyos intermitentes, por su parte, las herbáceas son abundantes, sobre todo en verano, y crecen con frecuencia bajo el dosel de los arbustos y otras en espacios abiertos. En

Tabla 1. Principales grupos que integran la flora vascular del matorral submontano de rosáceas.

División / Clase	Familias	%	Géneros	%	Taxa	%
Pteridophyta	2	4.08	6	4.17	7	3.14
Pinophyta	2	4.08	2	1.39	2	0.90
Liliopsida	6	12.24	32	22.22	51	22.87
Magnoliopsida	39	79.59	104	72.22	163	73.09
Total	49	100.00	144	100.00	223	100.00

Tabla 2. Comparación de la composición del matorral submontano de rosáceas de la Sierra de Zapalinamé con matorrales similares de México.

Comunidad vegetal	Matorral submontano de rosáceas (este trabajo)	Chaparral (Pinkava 1980)	Chaparral (Muller-1939; Rojas 1965; Valdez y Aguilar 1983)	Chaparral (González et al. 2007)	Vegetación esclerófila perennifolia (Flores et al. 1999)
Localidad/Estado	Sierra de Zapalinamé, Coahuila	Sierra de la Madera, Coahuila	Nuevo León	Durango	Valle de Tehuacán, Puebla
Altitud (m)	1,770 a 2,094	1600 a 1800	1,600 a 3,000	2000 a 2500	2280 a 2320
Malacomeles denticulata	X	X	X	X	X
Purshia plicata	X		X	X	
Lindleya mespiloides	X	X	X	X	X
Cercocarpus spp.	X	X	X	X	X
Quercus spp.	X	X	X	X	X
Rhus virens	X	X	X	X	X
Garrya ovata	X	X	X	X	X
Arbutus xalapensis	X	X	X	X	X
Arctostaphylos pungens	X	X	X	X	
Chrysactinia mexicana	X	X	X		X
Gymnosperma glutinosum	X	X	X		X
Fraxinus greggii	X	X	X		
Mimosa biuncifera	X			X	
Berberis trifoliolata	X				
Brickellia veronicifolia	X				
Sideroxylon lanuginosum	X				
Calia secundiflora		X	X		X
Ageratina spinosorum					X

la estructura vertical se diferencian cuatro estratos: el arbóreo (≥ 2 m de altura), el arbustivo superior (1 a 2 m), el arbustivo inferior (≤ 1 m) y el herbáceo. La cobertura vegetal con frecuencia es superior al 100%, sin embargo, a menor altitud el matorral presenta coberturas que varían entre 50 y 70%. Se registraron cuatro especies arbóreas con altura y diámetro promedio de 2.5 m y 17 cm respectivamente, la densidad total es 342 ind/ha, de los cuales el 50% corresponde a *Juniperus flaccida*; otras especies frecuentes son *Quercus saltillensis* y *Pinus cembroides*, cada una con densidad inferior al 25% del total registrado (Tabla 3). La densidad promedio de arbustos es de 12,475 ind/ha, de los cuales el 56.55% (7,055 ind/ha) forman parte del estrato inferior. Como parte del estrato arbustivo superior (mayor a 1 m) *Lindleya mespiloides*, *Malacomeles denticulata* y *Purshia plicata* dominan la fisonomía y estructura del matorral, especies que en conjunto constituyen el 72.93% de la cobertura vegetal, el 37.5% de la densidad total y el 44.13% del valor de importancia relativa (en lo sucesivo VIR); otras especies frecuentes son *Cercocarpus fothergilloides* y *Rhus virens*, sin embargo, sus valores estructurales son bajos (VIR menor a 1.8%). En el estrato arbustivo inferior se presenta *Mimosa biuncifera* con un VIR de 12.33%, otras arbustivas son: *Chrysactinia mexicana*, *Gymnosperma glutinosum* y *Berberis trifoliolata*, con un VIR entre

Tabla 3. Atributos estructurales del matorral de rosáceas de la Sierra de Zapalinamé.

Árboles (≥ 2 m de alto)							
Especie	**Altura media (m)**	**Diámetro medio (cm)**	**Dominancia relativa (%)**	**Densidad (ind/ha)**	**Densidad relativa (%)**	**Frecuencia relativa (%)**	**VIR (%)***
Juniperus flaccida	2.30	17	55.66	171	50.00	60.00	55.22
Quercus saltillensis	2.40	13	20.30	76	22.22	20.00	20.84
Pinus cembroides	2.50	22	11.57	76	22.22	10.00	14.59
Prunus serotina	2.40	18	12.46	19	5.55	10.00	9.33
			Arbustos (1 a 2 m de alto)				
Especie	Altura media (m)	Dominancia relativa (%)	Densidad (ind/ha)	Densidad relativa (%)	Frecuencia relativa (%)	VIR (%)*	
Malacomeles denticulata	1.84	29.80	1,536	12.41	8.00	16.73	
Purshia plicata	1.21	22.67	2,041	16.48	8.00	15.72	
Lindleya mespiloides	1.45	20.44	1,067	8.61	6.00	11.68	
Cercocarpus fothergilloides	1.17	1.27	99	0.79	1.60	1.22	
			Arbustos (≤ 1.0 m de alto)				
Mimosa biuncifera	0.66	11.34	2,087	16.86	8.80	12.33	
Chrysactinia mexicana	0.23	0.67	1,067	8.61	7.60	5.63	
Gymnosperma glutinosum	0.35	1.02	1,119	9.04	6.40	5.48	
Berberis trifoliolata	0.68	2.85	568	4.59	6.80	4.74	
Brickellia veronicifolia	0.33	0.62	551	4.45	6.80	3.95	
Condalia spathulata	0.46	0.49	122	0.98	3.60	1.69	
Otras especies (44)	0.67	8.78	2,122	17.14	36.40	20.77	
			Hierbas (0.10 a 0.30 m de alto)				
Especie	Altura media (m)	Dominancia relativa (%)	Densidad (ind/ha)	Densidad relativa (%)	Frecuencia relativa (%)	VIR (%)*	
Dyssodia papposa	0.14	0.83	60,000	22.27	1.79	8.30	
Muhlenbergia setifolia	0.25	15.68	4,706	1.74	2.15	6.53	
Bouteloua curtipendula	0.30	6.85	7,157	2.65	3.59	4.36	
Bouteloua hirsuta	0.18	6.27	8,333	3.09	1.79	3.72	
Loeselia coerulea	0.16	1.48	14,706	5.45	3.95	3.63	
Erioneuron avenaceum	0.15	3.71	10,490	3.89	2.87	3.49	
Crusea diversifolia	0.20	0.13	22,941	8.51	1.79	3.48	
Hedyotis nigricans	0.10	0.23	19,020	7.06	1.79	3.03	
Aristida pansa	0.28	5.78	2,549	0.94	2.15	2.96	
Thymophylla pentachaeta	0.12	3.91	7,059	2.62	2.15	2.89	
Otras especies (96)	0.20	55.07	112,451	41.73	75.89	57.57	

* VIR (Valor de importancia relativa) = (dom rel. + dens rel. + frec rel.)/3.

4 y 6%. En el estrato herbáceo se encontraron 106 especies, de las cuales la más representativa es *Dyssodia papposa*, herbácea anual con el 22.27% de la densidad total y el 8.3% del VIR, son importantes además tres especies de zacates: *Muhlenbergia setifolia, Bouteloua curtipendula* y *B. hirsuta*, las tres suman un VIR de 14.62%.

Los VIR de las especies arbustivas más importantes de la comunidad varían de manera considerable en relación con el aumento de la altitud (Fig. 2), con cambios en la dominancia de las especies cada 100 m sobre el gradiente de altitud (1,770 a 2,200 m). En las partes bajas y xéricas *Mimosa biuncifera* es la arbustiva con mayor densidad y las especies de rosáceas son poco frecuentes, mientras que en sitios a mayor altitud y más humedad *Purshia plicata* es la más abundante; los pisos altitudinales intermedios están dominados por *Lindleya mespiloides* y *Malacomeles denticulata*.

En el área se registraron 160 especies de las cuales 54 son arbustivas y 106 herbáceas (Tabla 4). La riqueza de arbustivas por sitio varía entre 7 y 17 (media de 12 especies), mientras que el de herbáceas fluctúa entre 6 y 27 (promedio de 16 especies por sitio). El estrato herbáceo tiene un índice de diversidad de 2.99 nats, por su parte en el estrato arbustivo es de 2.76 nats, la equitatividad de los dos estratos varía de 68.58 a 73.18%. El nú-

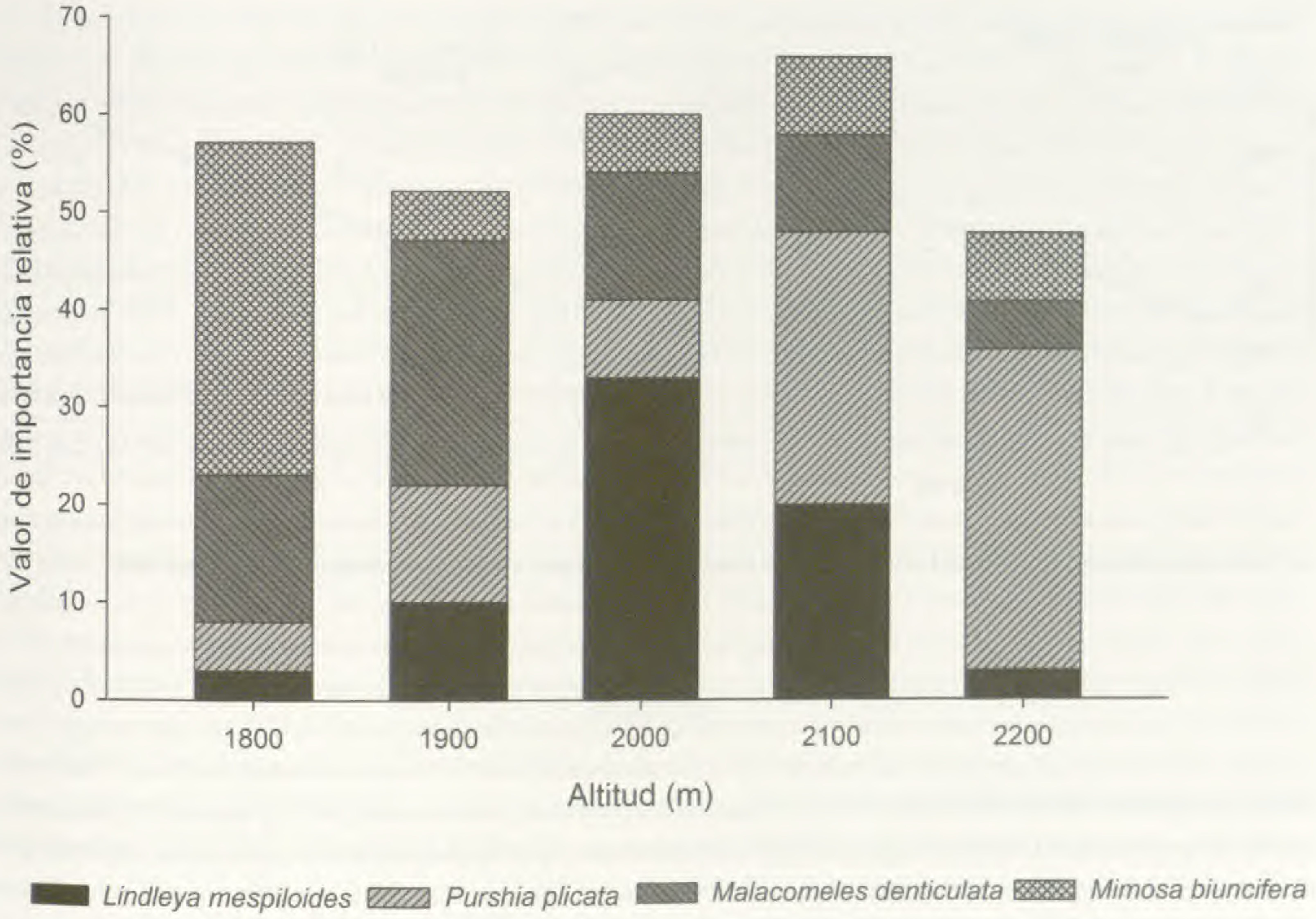

Fig. 2. Valores de importancia relativa de las especies dominantes del matorral submontano de rosáceas a través de un gradiente altitudinal.

Tabla 4. Riqueza de especies, diversidad y equitatividad del matorral submontano de rosáceas.

	No. de especies	Índice de diversidad (H`)	Diversidad máxima (H` max)	Equitatividad (%)
Estrato arbustivo				
Total	54	2.76	3.98	68.58
Promedio/sitio	12	1.75	2.37	75.60
Estrato herbáceo	**No. de especies**	**Índice de diversidad (H`)**	**Diversidad máxima (H` max)**	**Equitatividad (%)**
Total	106	2.99	4.50	73.18
Promedio/sitio	16	2.17	3.16	74.64

mero de especies arbustivas y el índice de diversidad de dicho estrato (Fig. 3) se relacionan de manera positiva-con la altitud a un promedio de incremento de 2.17 especies y 0.3 nats por sitio de muestreo cada 100 m de altitud, en condiciones homogéneas de exposición topográfica (noroeste).

La mayoría de los sitios de muestreo se ubicaron al pie de monte de la sierra, en laderas bajas y medias (valor de pendiente de 25 y 45%), en altitudes desde 1,778 hasta 2,220 m, con exposición topográfica hacia el noroeste. El sustrato geológico está formado a partir de rocas sedimentarias de tipo conglomerado, los suelos son pedregosos, moderadamente alcalinos, con valores medios en el contenido de materia orgánica y con una profundidad inferior a los 21 cm (Anexo 2).

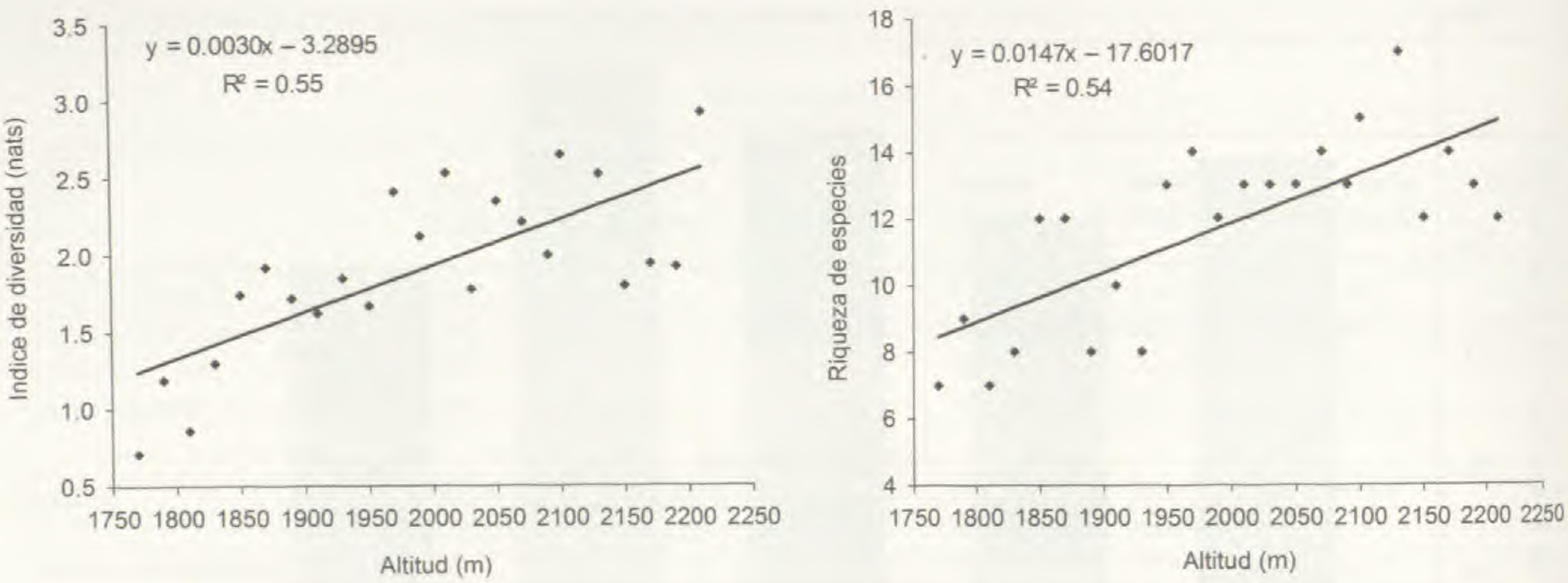

Fig. 3. Diversidad y riqueza de especies del estrato arbustivo en el matorral submontano de rosáceas a través de un gradiente de altitud.

DISCUSIÓN

La riqueza florística del matorral submontano de rosáceas equivale al 6.95% de la flora de Coahuila (Villarreal 2001) y representa el 53.79% de los 409 taxa registrados por Arce y Marroquín (1985) para la Sierra de Zapaliname. Esta comunidad ocupa el segundo lugar en riqueza de especies dentro del área protegida, superada por el bosque de encino, el cual presenta un total de 259 especies (Encina et al. 2007); la alta riqueza específica es atribuible a que se ubica en transición con otras comunidades como el matorral micrófilo, rosetófilo, bosque de pino y/o encino, además de que algunas especies son ruderales y su presencia se favorece por el impacto antrópico derivado de la cercanía con la zona urbana de la ciudad de Saltillo. Esta riqueza florística es superior a la del "Chaparral" de la Sierra de la Madera, Coahuila reportada por Pinkava (1980) de donde se registran 138 especies; un comparativo con la vegetación esclerófila perennifolia del valle de Tehuacán, Puebla, muestra altas similitudes en número, pues en dicha localidad se reportan 214 especies (Flores et al. 1999), la similitud florística a nivel de familia entre estas comunidades también se repite, ya que en ambos Asteraceae, Fabaceae, Lamiaceae, Euphorbiaceae, Poaceae y Rosaceae, tienen una mayor riqueza de especies; sin embargo, también se observan algunas diferencias como la mayor abundancia de Poaceae y Asteraceae en Zapalinamé, lo cual es atribuible a una mayor aridez y un clima más templado (Rzedowski 1978), además de que el área estudiada se ubica en la región con mayor diversidad de Asteraceas en Coahuila (Villarreal et al. 1996). En general la composición del matorral concuerda con la de otras comunidades arbustivas de climas templado secos de México, donde son mayoría las especies de afinidad holártica (Valiente et al. 1998). Los valores de diversidad calculados para el estrato arbustivo (2.76 nats) son superiores a los reportados por Estrada (1998) y Huerta y García (2004) para matorral submontano (1.03 y 1.88 nats); estas diferencias, aunadas a un moderada equitatividad (68.58%) del estrato, así como a una riqueza y diversidad alta de herbáceas son evidencia de la actividad antrópica en esta comunidad (Margalef 1991; Aronson y Schmida 1992). No obstante, la alta diversidad del matorral también puede ser debido a la transición con otras comunidades de la sierra, tal como lo mencionan Canizales et al. (2009), quienes concluyen que la alta diversidad del matorral submontano de Nuevo León se debe a la formación de ecotonos con otros tipos de vegetación. Encina et al. (2007) señalan una mayor diversidad de los bosques de encino en las partes bajas del macizo montañoso, a una altitud en la cual se da la transición con el matorral submontano de rosáceas, lo cual corrobora los resultados encontrados en el presente trabajo. El incremento de la diversidad en relación a la altitud, muestra que esta variable ecológica es la de mayor influencia en la diversidad del matorral, ya que en el área la mayor altitud se traduce en un incremento de la precipitación (obs. pers.), factor comúnmente asociado a una mayor diversidad en comunidades de zonas áridas y semiáridas (Aronson y Schmida 1992; Montaña y Valiente 1998).

El matorral de rosáceas de la Sierra de Zapalinamé forma parte del matorral submontano de Rzedowski (1966) y de manera general es equiparable a los chaparrales de Durango (González et al. 2007), Coahuila (Pinkava 1980), Desierto Chihuahuense (Henrickson y Johnston 1983) y Nuevo León (Muller 1939; Rojas 1965; Valdez y Aguilar 1983), al matorral submontano de Coahuila (Villarreal y Valdés 1992–93) y a la vegetación esclerófila perennifolia (Valiente et al. 1998; Flores et al. 1999). Si bien el comparativo florístico mostró mayor similitud entre las localidades más cercanas, todas se caracterizan por la dominancia estructural de arbustivas menores a 2 m de altura (principalmente de Fagaceae y Rosaceae), inermes y esclerófilas, con una cobertura del 100%, además de una elevada riqueza de herbáceas; no obstante, contrario a lo observado en dichas comunidades, en el área estudiada la estructura del matorral está dominada por especies de rosáceas, lo que ha llevado a considerarlo como una vegetación secundaria que se originó por la tala de bosques de pino y encino (Arce y Marroquín 1985). Sin embargo, no hay evidencias históricas que confirmen esta aseveración, además de que los bosques de pino se localizan a mayores elevaciones y en otros sectores de la sierra; aunque dos de las rosáceas dominantes (*Malacomeles denticulata* y *Purshia plicata*) creemos que su abundancia en el área se vincula directamente al clima y suelo, ya que dichas especies crecen junto con *Lindleya mespiloides* en climas templado-seco y en sustratos de origen calizo (Rzedowski y Calderón 2005). La mayor densidad de estas especies se presenta en las porciones más áridas (menor altitud o exposición sur) y en sustratos calizos; otros indicadores de mayor aridez en este matorral son la presencia de especies de afinidad xérica de las familias Cactaceae y Agavaceae. Los VIR de las especies de rosáceas presentaron variaciones con respecto a la altitud, lo cual refleja también la influencia de aspectos climáticos en la distribución de la comunidad y de las especies dominantes, resultados que concuerdan con Flores et al. (1999), quienes encontraron que *Malacomeles denticulata* es dominante en los pisos altitudinales inferiores, mientras que Valdez y Aguilar (1983) señalan que *Lindleya mespiloides* y *Purshia plicata* son abundantes en chaparrales ubicados en laderas altas con exposición sur, patrón altitudinal similar al que describen Rzedowski y Calderón (2005) para estas especies en el centro de México. Aunque el estrato arbustivo inferior presentó la mayor densidad y el mayor número de especies, mientras que el superior es el que tiene más importancia en la comunidad dado que contribuye al incremento de la diversidad, esto se observó en los sitos dominados por especies de este estrato (principalmente rosáceas) donde se presenta mayor riqueza de herbáceas, entre ellas de gramíneas; esto se debe a que las copas de los arbustos modifican la disponibilidad de luz y humedad, lo cual permite el establecimiento de las especies, tal como lo señalan Madrigal et al. (2007) quienes enfatizan la importancia del nodricismo en los matorrales mediterráneos de España. Desde una perspectiva general el matorral estudiado se encuentra dentro del rango ecológico descrito para el matorral esclerófilo perennifolio y los chaparrales del norte del país, los cuales se distribuyen en zonas montañosas, en altitudes superiores a los 1,500 m, en transición con climas templados y secos, sobre suelos poco profundos con un horizonte petrocálcico bien desarrollado (Valiente et al. 1998; González et al. 2007; Pinkava 1980; Valdez y Aguilar 1983); sin embargo, diferencias como una menor precipitación media anual (450 a 550 mm) hacen de esta comunidad una variante seca de dichos matorrales, donde la precipitación promedio varía entre 600 a 800 mm anuales; este déficit hídrico se traduce en una cantidad importante de elementos xerófilos en el matorral y una baja participación estructural de géneros de zonas más templadas y húmedas como *Quercus* y *Pinus*, así como en una menor altura de la vegetación.

El matorral submontano de rosáceas del área protegida de Zapalinamé es una de las comunidades más afectadas por actividades antrópicas, debido a que se ubica en los límites con la zona urbana de la ciudad de Saltillo. Esta cercanía ha propiciado la pérdida de 74% del matorral en solo 20 años debido a la urbanización y el cambio de uso de suelo (Portes 2001), actividades que también son consideradas como las principales causantes de pérdida y disminución de la diversidad en otras áreas protegidas de México (Figueroa et al. 2009), así como en ecosistemas cercanos a zonas urbanas (Pisanty et al. 2009). Otros factores como el pastoreo excesivo, los incendios, la extracción de materiales y la recreación mal planificada han modificado la estructura y composición del matorral (Arce y Marroquín 1985), efecto que se aprecia con mayor claridad en los sitios próximos a la ciudad donde *Mimosa biuncifera* es dominante; la presencia de esta arbustiva en sitios impactados concuerda con las observaciones de Melgoza (1977) para el matorral submontano de Nuevo León, quien atribuye su abundancia a la tala y extracción de materiales combustibles. Caso similar es el de *Gymnosperma glutinosum*, especie abundante en el área, la cual según Calderón y Rzedowski (2005) es frecuente en sitios perturbados. Otra arbustiva común en áreas impactadas es *Berberis trifoliolata*, favorecida por el sobreapacentamiento ya que éste, por ser de tipo selectivo, propicia el desarrollo de especies que el ganado no consume (Rzedowski 1978). El fuego también ha contribuido a la desaparición del matorral, ya que aunque los incendios no son frecuentes en el área (Portes 2001) se sabe que estos han eliminado a los arbustos de rosáceas y en su lugar se establecen *Mimosa biuncifera* y *Gymnosperma glutinosum* (obs. pers.), además de que incrementan la riqueza y diversidad de herbáceas, sobre todo de anuales y ruderales (Hobbs y Huenneke 1992) tal es el caso de *Dyssodia papposa* especie calificada como maleza de tipo ruderal (Villarreal 1983; Calderón y Rzedowski 2005) y en los matorrales estudiados presenta el mayor VIR para el estrato herbáceo; este proceso de cambio también se ha observado con el desmonte para desarrollo urbano y el posterior abandono de 60 ha de matorral en el año 2001 (E. Canales G. com. pers.). De continuar el manejo irracional de esta comunidad es posible su desaparición y la disminución en las poblaciones de especies como *Ferocactus pilosus*, *Mammillaria candida* y *Manfreda brunnea*, listadas en la NOM-059-SEMARNAT-2010 (SEMARNAT 2010), la primera bajo la categoría de Sujeta a Protección Especial (Pr) y las dos últimas Amenazadas (A), así como de *Quercus saltillensis*, encino endémico del sureste de Coahuila (Villarreal y Encina 2005) además de *Dichromanthus cinnabarinus*, orquídea poco frecuente en la Sierra de Zapalinamé (obs. pers.). Por lo anterior, se recomienda reforzar el plan de manejo del área protegida con especial énfasis en evitar la urbanización y el cambio de uso de suelo, principales factores causantes de la pérdida del matorral, es importante además disminuir el pastoreo, así como incrementar el control de los incendios forestales, los cuales modifican la estructura y composición. Aunque gran parte del matorral se encuentra dentro de la zona de amortiguamiento, es necesaria su conservación dado que contribuye a lograr los objetivos primordiales del área protegida que son la recarga de acuíferos, la conservación de la biodiversidad, sobre todo de las especies vulnerables (Anónimo 1998), así como la protección de los suelos y control de la erosión.

ANEXO 1

Listado florístico del matorral submontano de rosáceas de la Sierra de Zapalinamé.

Colectores: **A** = Leopoldo Arce González, **E** = Juan A. Encina Domínguez, **G** = Sergio G. Gómez Pérez, **H** = George Hinton, **M** = Jorge S. Marroquín, **V** = José A. Villarreal Quintanilla, **VR** = Jesús Valdés Reyna.

PTERIDOPHYTA

Aspleniaceae: *Asplenium resiliens* Kunze (G 340).

Pteridaceae: *Argyrochosma microphylla* (Mett. ex Kuhn) Windham (G 114), *Astrolepis cochisensis* (Goodd.) D.M. Benham et Windham (E 615), *Cheilanthes alabamensis* (Buckley) Kunze (G 116), *Cheilanthes eatonii* Baker (G 163), *Notholaena aschenborniana* Klotzsch (G 124), *Pellaea intermedia* Mett. ex Kuhn (A s.n.).

PINOPHYTA

Cupressaceae: *Juniperus flaccida* Schltdl. (E 1159).

Pinaceae: *Pinus cembroides* Zucc.

MAGNOLIOPHYTA

DICOTYLEDONEAE (MAGNOLIOPSIDA)

Acanthaceae: *Dyschoriste linearis* (Torr. et A. Gray) Kuntze (E 749).

Anacardiaceae: *Rhus microphylla* Engelm., *Rhus virens* Lindh. ex A. Gray (G 521).

Apocynaceae: *Mandevilla karwinskii* Hemsl. (G 598).

Asclepiadaceae: *Cynanchum kunthii* Standl. (E 750), *Gonolobus chrysanthus* Greenm. (G 276).

Asteraceae: *Ageratina calaminthaefolia* (Kunth) R.M. King et H. Rob. (G 517), *Ageratina calophylla* (B.L. Rob.) R.M. King et H. Rob. (G 344), *Ageratina havanensis* (Kunth) R.M. King et H. Rob. (G 176), *Ageratina saltillensis* (B.L. Rob.) R.M. King et H. Rob. (E 1194), *Ageratina wrightii* (A. Gray) R.M. King et H. Rob. (G 532), *Ageratina scordonioides* (A. Gray) R.M. King et H. Rob (E 1160), *Ageratum corymbosum* Zucc. (G 319), *Bidens bipinnata* L., *Bidens odorata* Cav. (G 329), *Brickellia laciniata* A. Gray (G 171), *Brickellia lemmonii* A. Gray var. *conduplicata* (B.L. Rob.) B. L. Turner (G 519), *Brickellia veronicifolia* (Kunth) A. Gray (G 520), *Calyptocarpus vialis* Lees. (G 291), *Chaetopappa parryi* A. Gray (G 265), *Chaptalia texana* Greene (G 117), *Chrysactinia mexicana* A. Gray (G 126), *Cosmos bipinnatus* Cav. (G 529), *Dahlia coccinea* Cav. (G 557), *Dyssodia papposa* (Vent.) Hitchc., *Dyssodia pinnata* (Cav.) Rob. var. *glabrescens* Strother (E 2073), *Erigeron pubescens* Kunth (G 498), *Fleischmannia pynocephala* (Lees) R.M. King et H. Rob. (G 324), *Gaillardia mexicana* A. Gray (G 509), *Gnaphalium semiamplexicaule* DC. (G 568), *Gochnatia hypoleuca* (DC.) A. Gray (G 335), *Gutierrezia sarothrae* (Pursh) Britton et Rusby (G 280), *Gymnosperma glutinosum* (Spreng.) Less. (E 2059), *Heliopsis parvifolia* A. Gray (G 550), *Heterotheca mucronata* V.L. Harms ex B. L. Turner (E 1263), *Heterotheca subaxilaris* (Lam.) Britton et Rusby (G 334), *Hymenoxys scaposa* (DC.) Parker (G 511), *Parthenium hysterophorus* L. (G 219), *Pinaropappus roseus* (Less.) Less. (G 369), *Porophyllum linaria* (Cav.) DC (G 343), *Psacalium peltatum* (Kunth) Cass. var. *adenophorus* Blake (G 345), *Sanvitalia angustifolia* Engelm. ex A. Gray (G 376), *Simsia amplexicaulis* Pers. (G 623), *Simsia calva* A. Gray (G 338), *Stevia serrata* Cav. (G 325), *Stevia tomentosa* Kunth (G 327), *Thelesperma simplicifolium* A. Gray (E 1215), *Thymophylla pentachaeta* Small (G 320), *Thymophylla setifolia* Lag. (G 292), *Verbesina hypomalaca* B.L. Rob. et Greenm. var. *saltillensis* B. L. Turner (G 513), *Verbesina rothrockii* B.L. Rob. et Greenm., *Viguiera brevifolia* Greenm. (G 534), *Wedelia acapulcensis* Kunth var. *hispida* (Kunth) Strother (G 294), *Zinnia acerosa* (DC.) A. Gray (G 282), *Zinnia peruviana* (L.) L. (G 348).

Berberidaceae: *Berberis trifoliolata* Moric. var. *glauca* (I.M. Johnst.) M.C. Johnst. ex Laferr. (E 1158).

Bignoniaceae: *Tecoma stans* (L.) Kunth var. *angustatum* Rehder (G 525).

Brassicaceae: *Lesquerella fendleri* (A. Gray) S. Watson (G 375), *Schoenocambre linearifolia* (A. Gray) Rollins (E 2062), *Thelypodium longipes* (Rollins) Rollins (E 2061).

Cactaceae: *Echinocereus stramineus* (Engelm.) Ruempler, *Ferocactus pilosus* (Gal.) Werder., *Mammillaria chionocephala* Purpus, *Mammillaria candida* Scheidw., *Mammillaria heyderi* Muehl., *Mammillaria winteriae* Boedeker, *Neolloydia smithii* (Muehlenpf.) Kladiwa et Fittkau in Krainz var. *beguinii* (F.A.C. Weber) Kladiwa et Fittkau in Krainz (G 646), *Opuntia stenopetala* Engelm., *Opuntia lindheimeri* Engelm.

Convolvulaceae: *Convolvulus arvensis* L. (G 278), *Dichondra argentea* Willd. (G 378), *Dichondra brachypoda* Wooton et Standl., *Evolvulus alsinoides* L. var. *hirticaulis* Torr. (G 342), *Ipomoea purpurea* (L.) Roth. (E 1168), *Ipomoea hederifolia* L. (G 481).

Crassulaceae: *Villadia aristata* R. Morán (G 372).

Ericaceae: *Arbutus xalapensis* Kunth (E 1272), *Arctostaphylos pungens* Kunth (E 1268).

Euphorbiaceae: *Acalypha lindheimeri* Müll. Arg. (G 296), *Acalypha monostachya* Cav. (G 389), *Argythamnia humilis* (Engelm. et A. Gray) Müll. Arg., *Croton dioicus* Cav. (V 565), *Euphorbia graminea* Jacq. (G 486), *Euphorbia villifera* Scheele (G 527), *Phyllanthus polygonoides* Spreng. (G 328).

Fabaceae: *Acacia berlandieri* Benth. (G 526), *Astragalus emoryanus* (Rydb.) Cory (G 223), *Astragalus sanguineus* Rydb. (E 1399), *Calliandra conferta* A. Gray (G 524), *Cercis canadensis* L. var. *mexicana* (Rose) Hopk. (G 507), *Cologania angustifolia* Kunth (M 3600), *Dalea aurea* Nutt. (E 2074), *Dalea bicolor* Willd. (E 1810), *Dalea eriophylla* S. Watson var. *eriophylla* (A s.n.), *Dalea greggii* A. Gray (G 522), *Dalea radicans* S. Watson (E 1211), *Desmodium grahamii* A. Gray (E 1212), *Eysenhardtia polystachya* (Ort.) Sarg. (G 279), *Mimosa biuncifera* Benth. (G 457), *Mimosa zygophylla* A. Gray

Fagaceae: *Quercus laceyi* Small (G 599), *Quercus mexicana* Kunth (G 150), Quercus pringlei Seemen (E 1493), *Quercus saltillensis* Trel. (E 687), *Quercus striatula* Trel. (G 533).

Garryaceae: *Garrya ovata* Benth. ssp. *ovata* (E 1260).

Grossulariaceae: *Ribes affine* Kunth (G 254).

Lamiaceae: *Hedeoma costatum* A. Gray (E 1261), *Poliomintha longiflora* A. Gray var. *longiflora* (G 347), *Salvia glechomifolia* Kunth (E 2070), *Salvia grahamii* Benth. (G 479), *Salvia greggii* A. Gray (E 1496), *Salvia reflexa* Hornem. (G 510), *Salvia regla* Cav. (E 1193), *Salvia roemeriana* Scheele (G 346), *Scutellaria potosina* Brandegee (E 1912).

Linaceae: *Linum rupestre* (A. Gray) Engelm. (E 1905).

Loasaceae: *Mentzelia incisa* Urb. et Gilg (E 2068).

Lythraceae: *Cuphea eaquipetala* Cav. (G 318).

Malvaceae: *Sida abutifolia* Mill. (G 285), *Sida spinosa* L. (G 297).

Nyctaginaceae: *Cyphomeris crassifolia* (Standl.) Standl. (G 289), *Mirabilis linearis* (Pursh) Heimerl (G 383), *Mirabilis oblongifolia* (A. Gray) Heimerl (V 1724).

Oleaceae: *Fraxinus cuspidata* Torr. (G 506), *Fraxinus greggii* A. Gray, *Menodora scabra* A. Gray (G 290).

Onagraceae: *Oenothera kunthiana* (Spach) Munz (G 259), *Oenothera texanensis* Raven et Parnell (G 260).

Orobanchaceae: *Orobanche ludoviciana* Nutt. (G 384).

Phytolaccaceae: *Phytolacca octandra* L. (G 523).

Piperaceae: *Peperomia campylotropa* Hill (G 605).

Polemoniaceae: *Gilia rigidula* Benth. var. *acerosa* A. Gray (G 299), *Gilia stewartii* I. M. Johnst. (G 484), *Loeselia coerulea* (Cav.) G. Don (V 538), *Loeselia greggii* S. Watson (E 1198).

Polygonaceae: *Eriogonum atrorubens* Engelm. var. *auritulum* Hess et Reveal (G 247), *Eriogonum ciliatum* Torr. (G 390), *Eriogonum greggii* Torr. et A. Gray (G 298).

Ranunculaceae: *Clematis drummondii* Torr. et A. Gray (G 514).

Rhamnaceae: *Condalia spathulata* A. Gray

Rosaceae: *Malacomeles denticulata* (Kunth) G.N. Jones (E 1157), *Cercocarpus fothergilloides* Kunth var. *mojadensis* (Schneid.) Henrickson (E 1257), *Cercocarpus montanus* Raf. (M 3587), *Lindleya mespiloides* Kunth (G 257), *Prunus serotina* Ehrh. var. *serotina* (G 508), *Purshia plicata* (D. Don) Henrickson (E 1156), *Vauquelinia corymbosa* Bonpl. ssp. *saltilloensis* Hess et Henrickson (M 3552).

Rubiaceae: *Bouvardia ternifolia* (Cav.) Schlecht. (E 1341), *Crusea diversifolia* (Kunth) Anderson (E 1199), *Hedyotis acerosa* A. Gray (G 312), *Hedyotis nigricans* (Lam.) Fosberg (E 1495), *Relbunium microphyllum* Hemsl. (M 3592).

Rutaceae: *Ptelea trifoliata* L. ssp. *coahuilensis* (Greene) Bailey (G 118).

Sapindaceae: *Ungnadia speciosa* Endl. (G 472).

Sapotaceae: *Sideroxylon lanuginosum* Michx. subsp. *rigidum* (A. Gray) T.D. Pennington (G 133).

Scrophulariaceae: *Castilleja tenuiflora* Benth. (M 2941), *Maurandya antirrhiniflora* Willd. (E 1148), *Mecardonia vandellioides* (Kunth) Pennell (G 382), *Penstemon lanceolatus* Benth. (V 886).

Verbenaceae: *Verbena bipinnatifida* Nutt. (G 283), *Verbena canescens* Kunth (V 563), *Verbena neomexicana* (A. Gray) Small (E 1147).

MONOCOTILEDONEAE (LILIOPSIDA)

Agavaceae: *Agave gentryi* Ullrich, *Agave lechuguilla* Torr., *Agave scabra* Salm-Dyck. (G 636), *Dasylirion cedrosanum* Trel. (G 616), *Manfreda brunnea* (S. Watson) Rose, *Nolina cespitifera* Trel. (G 610).

Commelinaceae: *Aneilema karwinskiana* (Roem. et Schult.) Wood. (G 155), *Aneilema linearis* (Benth.) Rohw. (G 371), *Commelina dianthifolia* Delile (G 495), *Commelina erecta* L. var. *angustifolia* (Michx.) Fern. (G 516).

Cyperaceae: *Carex schiedeana* Kunze (G 477).

Liliaceae: *Allium kunthii* G. Don (G 380), *Asphodelus fistulosus* L. (G 123), *Zephyranthes brevipes* (Baker) Standl. (G 255).

Orchidaceae: *Dichromanthus cinnabarinus* (LaLlave et Lex.) Garay (E 1195)

Poaceae: *Achnatherum eminens* (Cav.) Barkworth (G 309), *Achnatherum robusta* (Vasey) Barkworth (G 357), *Andropogon spadiceus* Swallen (G 604), *Aristida adscensionis* L. (G 392), *Aristida eludens* Allred et Valdés-Reyna (VR 2254), *Aristida gypsophylla* Beetle (G 353), *Aristida pansa* Woot. et Standl. (G 352), *Aristida purpurea* Nutt. var. *purpurea* (E 1205), *Bouteloua curtipendula* (Michx.) Torr. (E 1149), *Bouteloua dactyloides* (Nutt.) Columbus, *Bouteloua gracilis* (Kunth) Griffiths (G 394), *Bouteloua hirsuta* Lag. (G 303), *Bouteloua uniflora* Vasey var. *coahuilensis* Gould et Kapadia (G 403), *Elymus elymoides* (Raf.) Swezey (G 406), *Enneapogon desvauxii* Beauv. (G 402), *Eragrostis intermedia* Hitchc. (VR 3063), *Eragrostis palmeri* S. Watson (G 393), *Erioneuron avenaceum* (Kunth) Tateoka (G 306), *Erioneuron nealleyi* (Vasey) Tateoka (G 314), *Hilaria swallenii* Cory (G 333), *Leptochloa dubia* (Kunth) Nees (VR 3065), *Lycurus phleoides* Kunth (VR 3067), *Metcalfia mexicana* (Scribn.) Conert (VR 3070), *Muhlenbergia dubia* Hemsl. (E 1202), *Muhlenbergia emersleyi* Vasey (E 1201), *Muhlenbergia rigens* (Benth.) Hitchc. (VR 3068), *Muhlenbergia setifolia* Vasey (VR 3073), *Muhlenbergia tenuifolia* (Kunth) Kunth (VR 3072), *Nassella tenuissima* (Trin.) Barkworth (G 332), *Paspalum setaceum* Michx. var. *ciliatifolium* (Michx.) Vasey (G 614), *Piptochaetium fimbriatum* (Kunth) Hitchc. (G 500), *Schizachyrium sanguineum* (Retz.) Alst. (E 1208), *Setaria leucopila* (Scribn. et Merr.) Schum. (G 301), *Sorghastrum brunneum* Swallen (E 2063), *Tridens muticus* (Torr.) Nash var. *muticus* (E 1213), *Zuloagaea bulbosa* (Kunth) Bess (G 471).

ANEXO 2

Coordenadas de ubicación geográfica y datos físicos de los sitios de muestreo en el matorral submontano de rosáceas.

Sitio	Coordenadas Y	Coordenadas X	Altitud (m)	Exposición	Pendiente (%)	Tipo de suelo	Clase textural	pH
1	25.36608	100.96919	2,070	Noreste	30	Rendzina	Migajón arenoso	7.6
2	25.36741	100.95953	2,153	Norte	25	Rendzina	Migajón arcilloso	7.9
3	25.37670	100.95964	1,910	Norte	25	Rendzina	Migajón	8.0
4	25.37191	100.97662	1,838	Noreste	8	Rendzina	-	-
5	25.34401	101.00778	1,993	Norte	30	Rendzina	Arcilla arenoso	7.8
6	25.34611	101.00260	1,950	Noroeste	28	Rendzina	Migajón arenoso	7.8
7	25.33404	100.99154	2,130	Noroeste	30	Litosol	Migajón arcilloso	7.8
8	25.33818	100.98583	2,100	Suroeste	30	Litosol	-	-
9	25.38273	100.94867	1,859	Noroeste	8	Rendzina	-	-
10	25.38286	100.94300	1,830	Noroeste	7	Rendzina	-	-
11	25.37328	100.97420	1,834	Noroeste	8	Rendzina	Migajón arcilloso arenoso	7.8
12	25.35866	100.98956	1,907	Noroeste	8	Rendzina	-	-
13	25.36344	100.94185	2,220	Noreste	30	Litosol	Arcilla	7.9
14	25.35771	100.98207	2,170	Noroeste	45	Litosol	Migajón arenoso	7.7
15	25.35866	100.98956	1,907	Norte	30	Rendzina	Migajón arcilloso arenoso	7.4
16	25.35435	100.99860	1,978	Noroeste	24	Rendzina	-	-
17	25.36222	100.93573	2,200	Noroeste	35	Litosol	-	-
18	25.36717	100.97111	2,035	Noroeste	25	Rendzina	-	-
19	25.36723	100.96449	2,090	Noroeste	15	Rendzina	Migajón arenoso	7.8
20	25.35048	100.99920	2,010	Noroeste	30	Rendzina	-	-
21	25.37496	100.97194	1,820	Noroeste	20	Rendzina	-	-
22	25.38092	100.95592	1,778	Noroeste	8	Xerosol haplico	-	-
23	25.37773	100.95572	1,794	Noroeste	15	Rendzina	-	-

AGRADECIMIENTOS

Agradecemos al herbario ANSM de la Universidad Autónoma Agraria Antonio Narro las facilidades brindadas para la realización del presente trabajo, a José A. Villarreal por su ayuda en la determinación de las especies colectadas. Se agradece a Oscar L. Briones, Socorro González E., así como a los revisores anónimos por las valiosas sugerencias para mejorar el manuscrito. De igual forma a Felipe N. Hernández S. por la elaboración del mapa del área de estudio, a Gualberto J. Pérez por elaborar la Figura 2, así como al personal del área protegida "Sierra de Zapalinamé" por su apoyo durante la toma de datos de campo.

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FLORA OF TINAJAS ALTAS, ARIZONA—A CENTURY OF BOTANICAL FORAYS AND FORTY THOUSAND YEARS OF *NEOTOMA* CHRONICLES

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ABSTRACT

This flora of the vascular plants of the Tinajas Altas region, within the Lower Colorado Valley subdivision of the Sonoran Desert of southwestern Arizona, includes the present-day species as well as fossils recovered from packrat middens. The vegetation and flora are dynamic, changing even now, and have changed dramatically during the past millennia, along with shifting climate and human presences. This is the first publication for any region of a comprehensive temporal flora and spans more than 43,000 years of plants inadvertently collected and curated by packrats (*Neotoma* spp.) and more recently by botanists. We document a present-day flora of 227 species in 175 genera and 46 families. We also document at least 119 species in 96 genera and 36 families from the fossil record and among these fossils at least 28 species in 17 genera and 6 families are no longer present in the region. The most diverse families, present-day and fossil taxa, are Asteraceae, Poaceae, Boraginaceae, Cactaceae, Brassicaceae, Fabaceae, Solanaceae, Euphorbiaceae, Polygonaceae, and Nyctaginaceae. The most diverse genera are *Cryptantha*, *Ambrosia*, and *Eriogonum*. There are 12 non-native species in the flora, representing only 5.3% of the modern flora, but only Sahara mustard (*Brassica tournefortii*) and Arabian grass (*Schismus arabicus*) are likely to negatively impact the native plants.

The famous waterholes, the Tinajas Altas, were critical for desert travelers and prehistoric people. The Tinajas Altas Mountains, in one of the most arid parts of North America, have one of the richest fossil records for Ice Age plants in the world. The radiocarbon-dated plant assemblages provide a detailed record of dramatic changes in geographic ranges of species and the succession from Ice Age woodlands to modern desertscrub. Prior to 11,000 years ago in the middle and late Wisconsin, Ice Age woodlands with single-leaf pinyon (*Pinus monophylla*), California juniper (*Juniperus californica*), Utah juniper (*Juniperus osteosperma*), Sonoran scrub oak (*Quercus turbinella*), and Joshua tree (*Yucca brevifolia*) were at Tinajas Altas and elsewhere in Sonoran Desert lowlands. The earliest known creosotebush (*Larrea divaricata*) in North America, 18,000 years before present, from a Tinajas Altas midden, was already the modern tetraploid Sonoran Desert race.

The Tinajas Altas region encompasses 80,000 acres (32,375 hectares) adjoining the western margin of the Cabeza Prieta National Wildlife Refuge and is within the Barry M. Goldwater Range. Scientific, cultural, and aesthetic values dictate that the Tinajas Altas should receive increased attention and protection.

RESUMEN

El presente reporte de la flora de las plantas vasculares de la región de las Tinajas Altas en el Desierto Sonorense del suroeste de Arizona incluye tanto las especies actuales como especies fósiles conservadas en depósitos antiguos de ratas de campo (*Neotoma* spp.). Actualmente la flora y la vegetación son dinámicas y siguen modificándose, pero en el último milenio los cambios han sido dramáticamente influenciados por el clima cambiante y la presencia humana. Esta es la primera documentación en cualquier región de una flora integral que abarca más de 43,000 años de plantas inadvertidamente colectadas y preservadas por las ratas de campo y en época reciente por los botánicos. Aquí documentamos la presente flora consistente en 227 especies de 175 géneros y 46 familias. Asimismo documentamos al menos 119 especies de 96 géneros y 36 familias

J. Bot. Res. Inst. Texas 6(1): 157 – 257. 2012

como fósiles, de los cuales al menos 28 especies, 17 géneros y 6 familias ya no existen en el área. Las familias más diversas, tanto actuales como fósiles, son Asteraceae, Poaceae, Boraginaceae, Cactaceae, Brassicaceae, Fabaceae, Solanaceae, Euphorbiaceae, Polygonaceae y Nyctaginaceae. Los géneros más diversos son *Cryptantha*, *Ambrosia* y *Eriogonum*. La flora incluye 12 especies exóticas, que representan tan sólo el 5.3% de la flora moderna, pero sólo la mostaza del Sahara (*Brassica tournefortii*) y el zacate árabe (*Schismus arabicus*) probablemente tendrán un impacto negativo en las plantas nativas. Estas famosas tinajas eran una fuente de agua indispensable para los viajeros del desierto y los habitantes prehistóricos. La Sierra de las Tinajas Altas ubicada en una de las regiones más áridas de Norteamérica tiene uno de los registros fósiles de plantas más diversos de la Edad de Hielo del mundo. Las plantas datadas con radiocarbono muestran un registro detallado sobre cambios dramáticos en los rangos geográficos de especies y sucesiones ecológicas desde los bosques de la Edad de Hielo al matorral desértico moderno. Los bosques de la Edad de Hielo con *Pinus monophylla*, *Juniperus californica*, *J. osteosperma*, *Quercus turbinella* y *Yucca brevifolia* se encontraban en las Tinajas Altas y en otras regiones bajas del Desierto Sonorense hace 11,000 años durante el período Wisconsin Medio y el Wisconsin Tardío. El registro más antiguo de gobernadora (*Larrea divaricata*) en Norteamérica, 18,000 años antes del presente, de un depósito de rata de campo, representa la raza tetraploide moderna del Desierto Sonorense. La región de las Tinajas Altas formó parte del refugio de vida silvestre *Cabeza Prieta National Wildlife Refuge* y actualmente del *Barry M. Goldwater Range*. Los valores científicos, culturales y estéticos sugieren que las Tinajas Altas deben recibir mayor atención y protección.

INTRODUCTION

The Tinajas Altas, or High Tanks, are famous through history and were utilized for millennia by Native Americans (Broyles et al. 2012). If you were traveling across the Camino del Diablo, part of the old Yuma-Caborca trail, you would head for the Tinajas Altas (Fig. 1). Sometimes the lower tanks would be dry and getting to the upper tanks could be daunting, and some travelers did not know about the upper pools or were not able to reach them. Missing the tinajas and their water could spell death to desert travelers. The importance of Tinajas Altas grew during the California gold rush of the mid-nineteenth century and by the end of that century they became a focus for desert research by the likes of WJ McGee and Edgar Mearns. Mearns (1907: 122) wrote, "This important station is at the east base of the [mountains], beside the lowest of a chain of natural rock tanks, in a steep ravine, containing an unfailing and almost inexhaustible supply of good water. The upper tanks are easily overlooked and difficult of access, which facts afford the most plausible explanation of the loss of lives of many persons whose bones and graves were thickly scattered about our camp" (Figs. 2 & 3).

The Tinajas Altas Mountains are a rugged range, rising 500 meters from the desert floor of southwestern Arizona. There are no foothills, only slabs of pale Eocene granite rising abruptly at an unlikely angle of 45 degrees (Fig. 4). Along a skyline fretted with spires and windows there are no trees or saguaros to provide scale, no sense of near or far. If you camp in a comfortable arroyo near the foot of the mountains and look to the peaks on a full-moon evening the Tinajas Altas are as brilliant as snow and as eye-popping as any great mountain (Fig. 5). The extremely arid Tinajas Altas region is situated along the Mexican border at a remote edge of the Barry M. Goldwater Range, about 70 km southeast of Yuma, Arizona (Fig. 6). The Tinajas Altas Mountains are 35 km long, trending southeast-northwest from the international border to the Gila Mountains, where the granite is rather dramatically replaced by dark schist. The Tinajas Altas site (the waterholes) is about 6.5 km north of the Mexican border and is reached by the Camino del Diablo, a graded dirt road running south from Interstate 8 and then eastward across the Lechuguilla Valley and the Cabeza Prieta National Wildlife Refuge. In spite of many visitors, the mountains and much of the adjacent valleys remain in near pristine condition, although the upper bajadas and various other areas continue to be severely impacted by illegal off-road driving and other recreational activities, and more recently by the massive construction activity of the U.S. border fence in 2008 (see Department of Homeland Security 2008).

We selected the flora area because of the rich fossil and modern botanical record and because it embraces a variety of desert habitats, is a convenient biological and cultural zone (delineated by U. S. Fish and Wildlife Service) and is an area of major conservation concern. The core flora area is the 80,000 acres (32,375 hectares) of the Tinajas Altas region encompassing the Tinajas Altas Mountains from the Cipriano Pass to the Mexico border at Frontera Canyon and the south end of the Lechuguilla Valley drained northward by Coyote Wash and southward by La Jolla Wash (Fig. 7). We also include some plant records from the nearby Butler Mountains

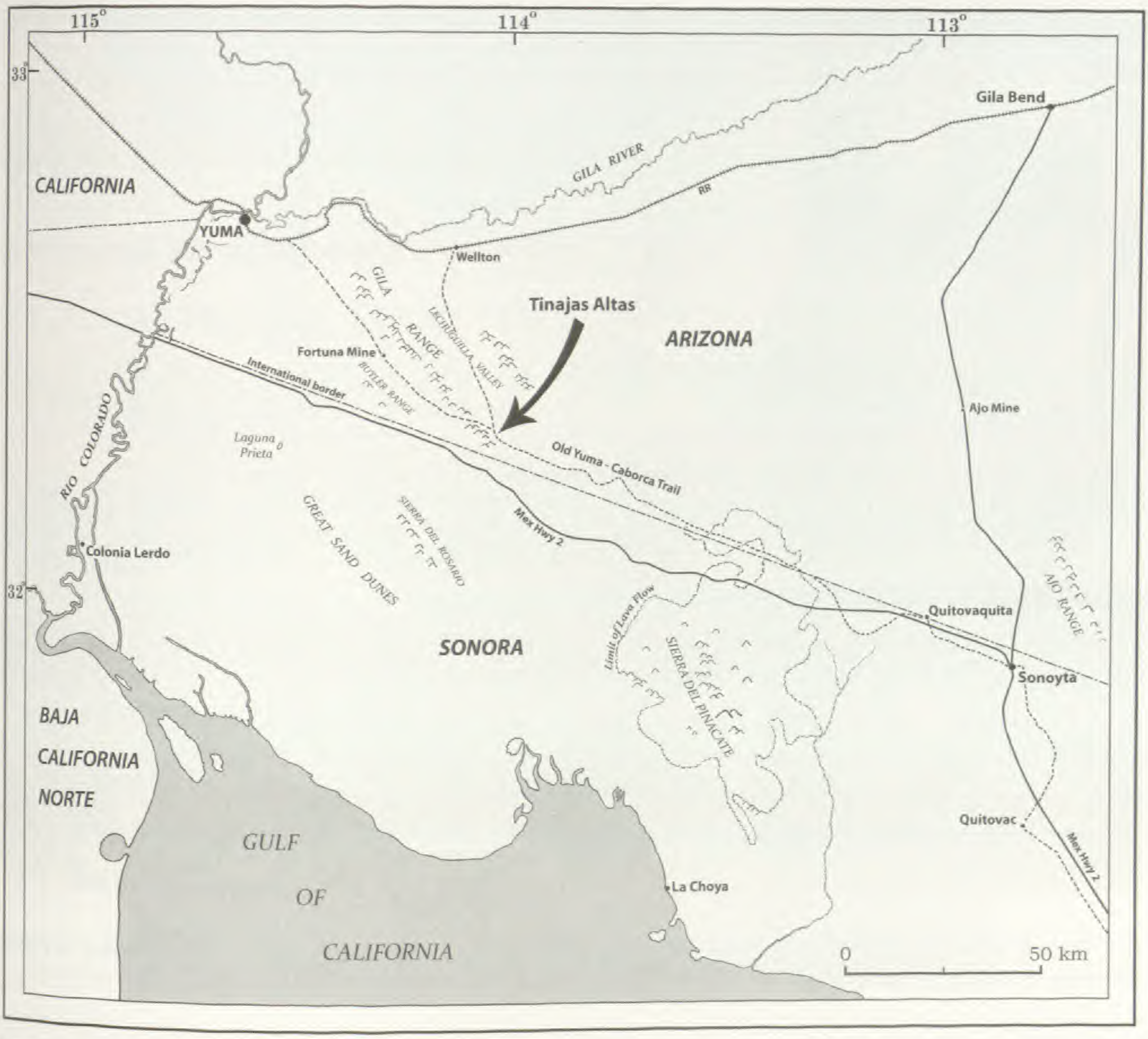

115°
114°
113°
33°
32°
CALIFORNIA
YUMA
GILA RIVER
RR
Gila Bend
Wellton
GILA RANGE
LECHUGUILLA VALLEY
Tinajas Altas
ARIZONA
Fortuna Mine
International border
BUTLER RANGE
Ajo Mine
Laguna Prieta
Old Yuma - Caborca Trail
RIO COLORADO
GREAT SAND DUNES
SIERRA DEL ROSARIO
Mex Hwy 2
Colonia Lerdo
Limit of Lava Flow
SIERRA DEL PINACATE
Quitovaquita
AJO RANGE
SONORA
Sonoyta
BAJA CALIFORNIA NORTE
GULF OF CALIFORNIA
Quitovac
Mex Hwy 2
La Choya
0
50 km

Fig. 1. The Gran Desierto and Camino del Diablo (Quitobaquito–Yuma portion of the Old Yuma–Caborca Trail) and surrounding regions, adapted from map in Lumholtz (1912). Drafted by Cathy Moser Marlett.

to provide perspective for the Ice Age record. A few records from immediately adjacent areas are included when we expect them to occur in the core area. Specific geographic information is given in the regional gazetteer by Broyles et al. (1997, 2007) and abridged in the list of place names below.

The Tinajas Altas region is nested among five major, contiguous protected areas and a sixth de facto area that make up the heart of the Sonoran Desert: Organ Pipe Cactus National Monument, Cabeza Prieta National Wildlife Refuge, and Sonoran Desert National Monument in Arizona, and Reserva de la Biosfera El Pinacate y Gran Desierto de Altar in Sonora and Reserva de la Biosfera Alto Golfo de California y Delta del Río Colorado in Sonora and Baja California. The Barry M. Goldwater Range in Arizona is not a protected area per se but generally is managed as one by the Air Force and the Marines. Spanning 210 miles (338 km) from San Felipe, Baja California, to just southwest of Phoenix, Arizona, these reserves cover 7,515,221 acres (3,041,410 ha), or 11.7 percent of the Sonoran Desert, making them the largest zone of contiguous protected desert anywhere in the Americas (Felger et al. 2007a). Felger et al. (2007b) documented a flora for this bio-network that included 845 vascular plant taxa (species, subspecies, and varieties) in 439 genera and 104 families, including 85 non-native species (Felger et al. 2007b). Some additional records have been discovered since then (e.g., Felger et al. 2012). This is more than one-third of the total flora of the entire Sonoran Desert, a region covering 100,000 mi^2 (310,000 km^2) in five states in Mexico and the United States (Shreve 1951).

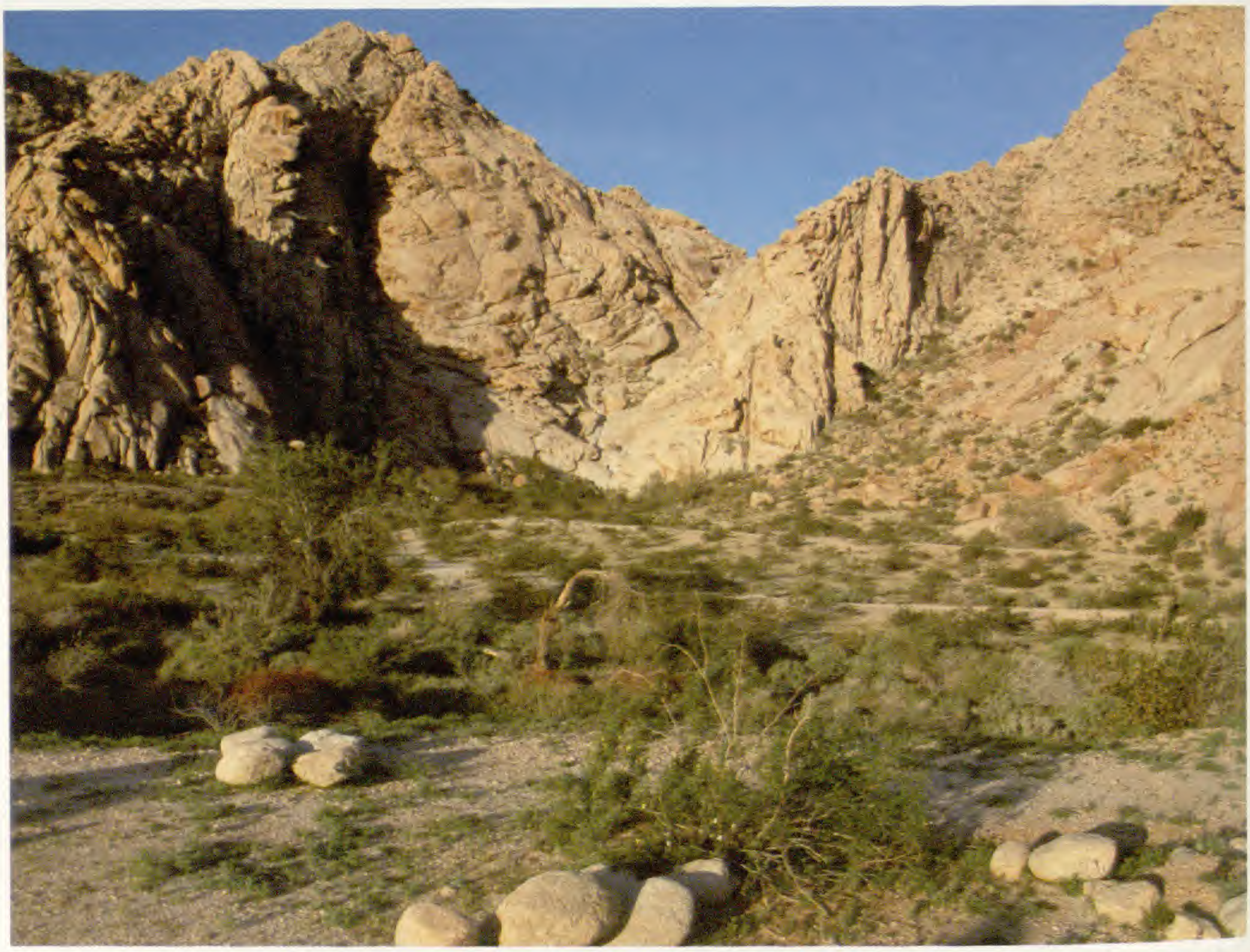


Fig. 2. Tinajas Altas, looking westward from the Mesa del Muerto. The tinajas cascade down from the steep rock slope from the notch or low point on the horizon. 29 March 2010. Photo by Joan Scott.

Plants of the Tinajas Altas region have been collected inadvertently by packrats (*Neotoma* spp.) for more than 43,000 years in fossil amberat and purposefully collected by botanists for more than a century. Together these two lines of collecting document a unique record revealing both the deep ecological history of the Sonoran Desert and its vegetation, as explained in a section by Van Devender, and the broad, fascinating range of modern-day plants and their species relationships, as compiled by Felger from his own field studies and those of his colleges and predecessors. In a section on botanizing and a list of collectors, we pay tribute to the role of curious collectors and the process of collecting, reminding readers of the fulfilling joy of discovery. Other sections on geology, climate, human history, land management, and place-names expand our knowledge and appreciation of this special place and provide a baseline as we look from the deep past to the future. Sites like Tinajas Altas will be key stations for studies of global climate change and its effects on particular biological communities. Meanwhile, perseverant neotomas continue to gather floral data.

GEOLOGY

The Tinajas Altas Mountains are linear and narrow with steep slopes, rugged canyons, and higher peaks standing 400–500 meters above the valley floor. Typical of Basin-and-Range tectonics, the range is block-faulted, trends northwest, and is separated from neighboring ranges by broad alluvial valleys or plains. The geology of Tinajas Altas has been strongly influenced by movement of the North American, Pacific, and Farallon continental plates. The Tinajas Altas range batholith is mainly composed of light-colored Gunnery Range granite exposed following the Laramide Orogeny (Figs. 2–4). Basaltic lava dating from the mid-Tertiary Orogeny (16–10 mya) crowns the adjacent Raven Butte (Figs. 8 & 9) as well as Tordillo Butte visible east of Tinajas Altas;

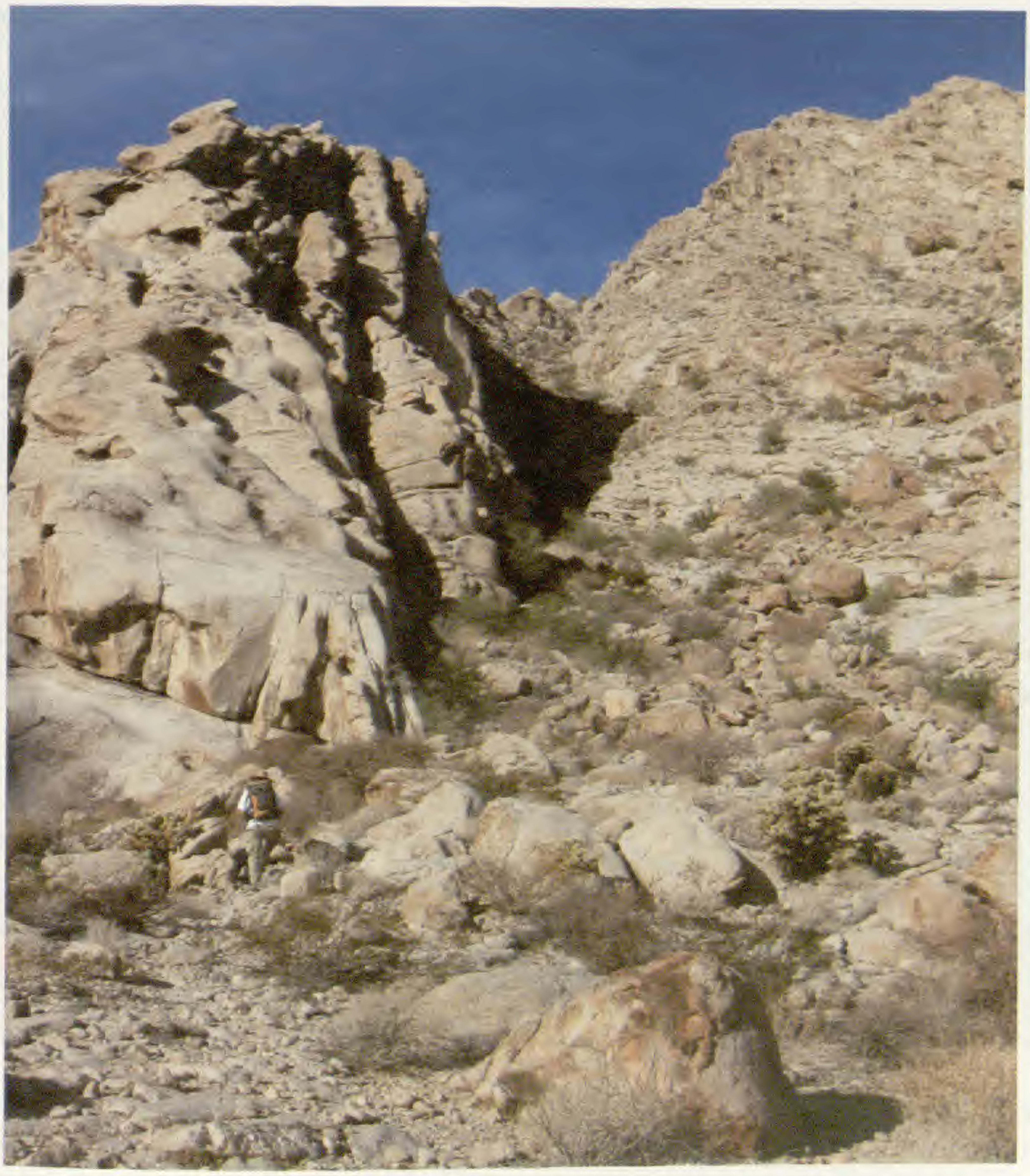


FIG. 3. Tinajas Altas Mountains, looking westward. The steep slope is just north of the tinajas and is the access to the uppermost tinajas and Tinajas Altas Canyon (the upper canyon above the tinajas). *Cylindropuntia bigelovii* in foreground. 21 November 2008. Photo by RSF.

the dark andesite and latite cap of Cabeza Prieta Peak dates to this time, too (Kresan 2007; Shafiqullah et al. 1980). Within the past 5.5 to 4.5 million years rifting and subsidence created the proto-Gulf of California and Salton Basin as well as an inland sea that reached as far as modern Phoenix, Arizona, and Las Vegas, Nevada, and surrounded Tinajas Altas before retreating (Ledesma-Vásquez & Carreño 2010; see Lucchitta et al. 2001, and Spencer & Pearthree 2001). At that time the Colorado River had a much different course than today (Young & Spamer 2001). Over the past 1.6 million years strike-slip faulting opened several off-set passes through the main range (Tucker 1980), but the range shows little recent uplift or lateral movement (Biggs & Demsey 2000). Granite bedrock has been the source for virtually all of the sediment in the Tinajas Altas area. Erosion occurs primarily by infrequent bursts of rainfall runoff. Tributary channels are dendritic and the broad valley floors are characterized by large, ephemeral washes that flow roughly along the central axis of the valleys (Biggs & Demsey 2000). Striking geologic features include tafoni, inselbergs, and embayments.

CLIMATE

Hot and dry! Nothing defines a desert like the Sonoran more than high temperatures and the paired factors of low rainfall and unpredictability—or variability, as shown so elegantly by Shreve (1951) and then by Ezcurra and Rodrígues (1986) and Comrie and Broyles (2002). Climate variability is the norm, as rainfall fluctuates on time scales ranging from seasons and years to millennia. Plant distributions and growth in general are delim-

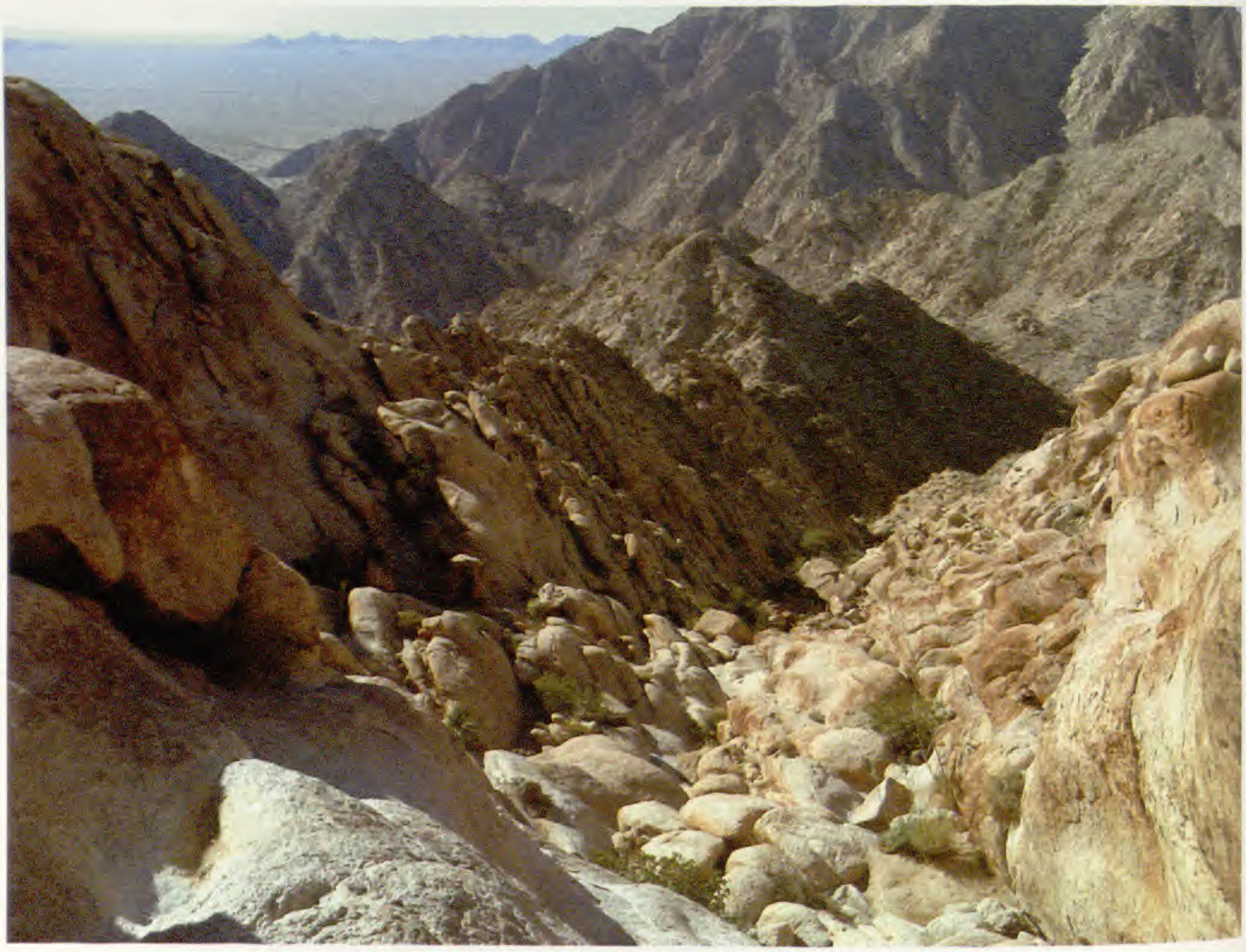


FIG. 4. Upper elevations along the east side of Tinajas Altas Mountains. 16 March 2011. Photo by JM.

ited in the Tinajas Altas region by drought and heat, especially the seasonal drought and hot weather of late spring and early summer. Wintertime freezing also may play a role for some plants. This brief climate summary incorporates information from Adams and Comrie (1997), Comrie and Broyles (2002), McGee (1906), Sellers et al. (1985), and Sheppard et al. (2002), as well as our own observations. The nearest long-term weather data, from Wellton (40 km to the north) and Yuma (about 70 km to the west), are summarized in Tables 1 and 2.

Summers are long and hot, and winters mild and relatively warm. Rainfall, however, varies wildly—with perhaps 7.6–10.2 cm (3–4 in) average at Tinajas Altas. Rainfall is bimodal, with summer rains and winter-spring rains, although summer rainfall is often nonexistent, rare, or substantially reduced. Summer monsoons, generally occurring July to September, are a northern extension of a tropical phenomenon, and greatly reduced from neighboring regions at somewhat higher elevations to the east, such as most of the Cabeza Prieta Refuge and Organ Pipe Cactus National Monument. Summer rains average about one-third as much as the cool-season rains. Often highly localized and violent, summer thunderstorms can bring heavy rainfall of brief duration, but such rains tend to be sporadic, spotty, and undependable, often drenching one place and leaving adjacent places bone dry. Occasional downpours produce flashfloods in the Tinajas Altas Canyon (Fig. 10), scouring the pools and removing or preventing vegetation in or adjacent to the pools.

Fall can be dry, or the occasional hurricane-fringe or tropical depression storms in late summer and fall ("backdoor monsoons") can dump substantial amounts of rain over great expanses, turning the desert green. These rains can result in spectacular development of the major perennials because the plants are often already in an active state of growth from the summer monsoon—the soil is still relatively moist and the weather still warm. Monsoonal thunderstorms or tropical Gulf of California hurricane-fringes on rare occasions can surpass

TABLE 1. Yuma Valley climate summary. November 1, 1930 to December 31, 1992, maximum average temperature (F), average minimum temperature (F), and average total rainfall (inches). From www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?azyuva (Verfied 14 July 2008).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann.
Max av. T	68.4	73.3	78.4	85.9	93.3	101.1	105.5	104.4	100.5	90.7	77.8	69.2	87.4
Min av. T	37.7	40.5	44.9	50.7	57.2	64.1	73.9	74.0	66.9	55.1	43.9	38.6	54.0
Av. rainfall	0.35	0.27	0.26	0.12	0.01	0.01	0.17	0.46	0.31	0.27	0.20	0.42	2.86

TABLE 2. Wellton, Arizona, climate summary. March 18, 1922 to December 31, 1980, maximum average temperature (F), average minimum temperature (F), and average total rainfall (inches). From www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?azwell). (Verified 14 July 2008).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann.
Max av. T	67.8	73.0	78.3	85.5	93.7	102.0	106.5	104.5	100.5	90.1	77.0	68.7	87.3
Min av. T	34.5	38.9	43.7	49.9	57.1	65.2	76.1	75.6	67.5	54.1	41.0	35.0	52.3
Av. rainfall	0.45	0.40	0.34	0.12	0.03	0.02	0.38	0.69	0.57	0.36	0.23	0.58	4.18

12.7 cm (5 in) in a single event. Once in a while these hurricane-fringe or tropical cyclone/depression rains bridge the summer monsoon and winter rains. This happened in the flora area in late September 2003 as a result of Tropical Depression Marty, when summer annuals continued growing and flowering intermixed with early germination and flowering of winter-spring (cool-season) annuals. A similar situation occurred in fall 2004.

Cool-season (winter-spring) rains, frontal storms originating in the Pacific Ocean, may begin as cooler weather approaches in November and can variously occur off and on through March or early April. Typically these rains are gentler than the summer rains and can deliver widespread precipitation. Sporadic El Niño years sometimes bring exceptional amounts of winter-spring rains, which can result in spectacular displays of spring wildflowers. This being an extremely arid region, the cool-season rains are often scanty or insignificant, such as during a La Niña year, e.g., 2011 (CLIMAS 2011).

April and especially May and June become increasingly hot and dry—desiccating is an appropriate word. The hot weather and seasonal drought of late spring and early summer, the fore-summer of Shreve (1951), severely limit the survival and distribution of Sonoran Desert plants. Spring annuals dry up and die and many trees and shrubs lose their leaves and some may even perish during the driest years. High temperatures rival records set elsewhere in North America and frequent winds intensify the aridity. Maximum daily temperatures commonly exceed 38–45°C (100–113°F) from late April to early October. Summer temperatures in the region are known to sometimes exceed 48.9°C (120°F)—on 28 July 1995, Yuma reached its all-time high at 51°C (124°F). Average July maximum temperatures are 40.6°C (105°F).

Average winter daytime temperatures are about 24°C (75°F) and average monthly minimum winter temperatures are about 4.4°C (40°F). Temperatures commonly dip several degrees below freezing on a few nights during each of the colder months. Many species in the region are frost sensitive, e.g., *Bursera microphylla* and *Jatropha cuneata*. Certain places or microhabitats, however, can be nearly or entirely frost-free, permitting a number of species with subtropical affinities to thrive. Such microhabitats include niches among granitic rock shelf and cliff bases, and solid rock slopes and aprons that channel water and often provide shade in summer as well as radiant heat in winter.

It is impressive to find the vegetation and flora so rich and varied in this extremely arid place.

HUMAN HISTORY

Culturally Tinajas Altas is in the Western Papaguería region near the intersection of three major groups: Hohokam, Trincheras, and Patayan (McGuire & Schiffer 1982). Because water is a limiting factor for human activities, the tinajas likely have been a focus of interest since people first arrived in the region during the Paleo-

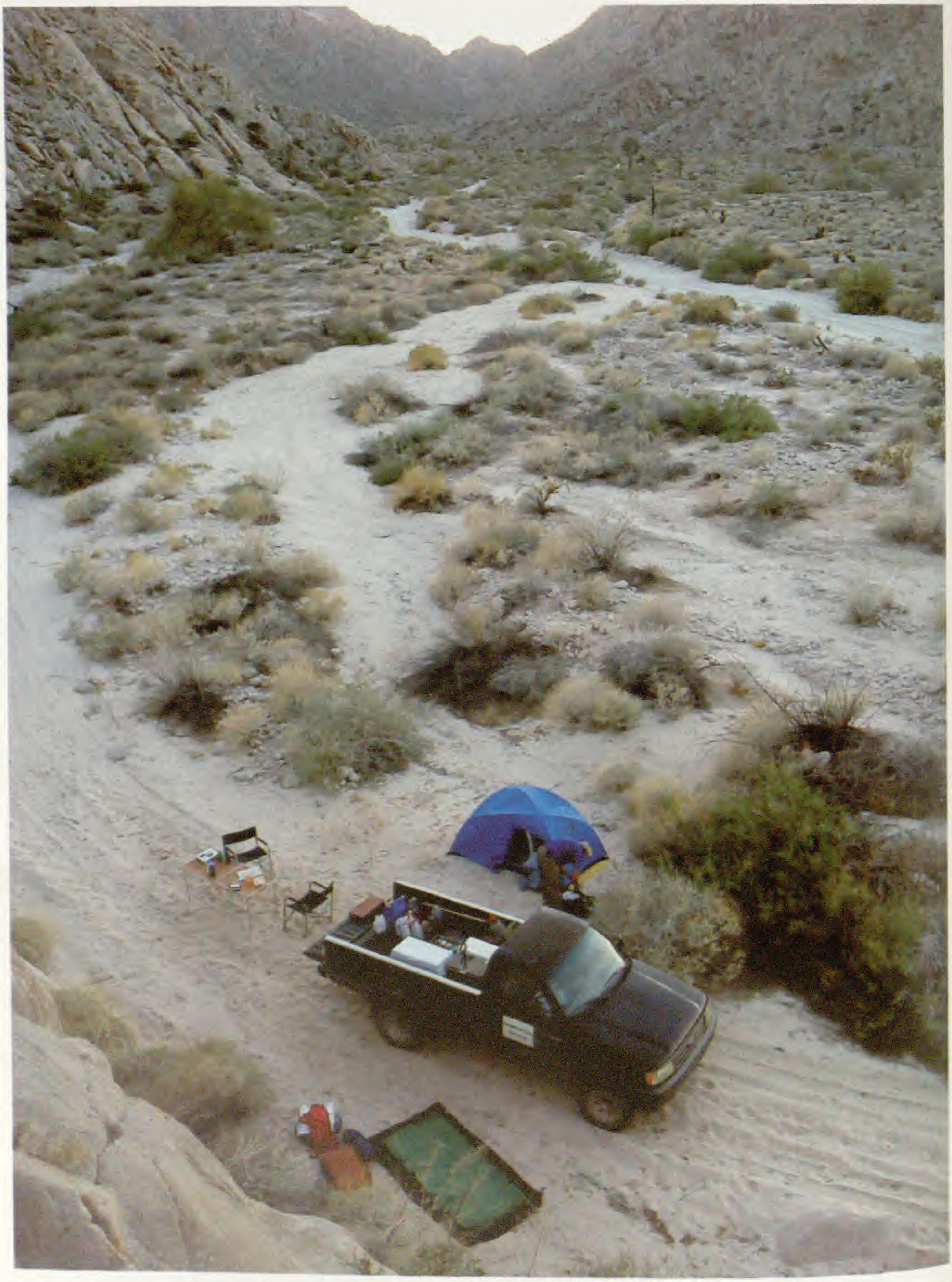


Fig. 5. Jim Malusa and Pete Sundt camping in the Tinajas Altas Mountains. 1 April 2011. Photo by JM.

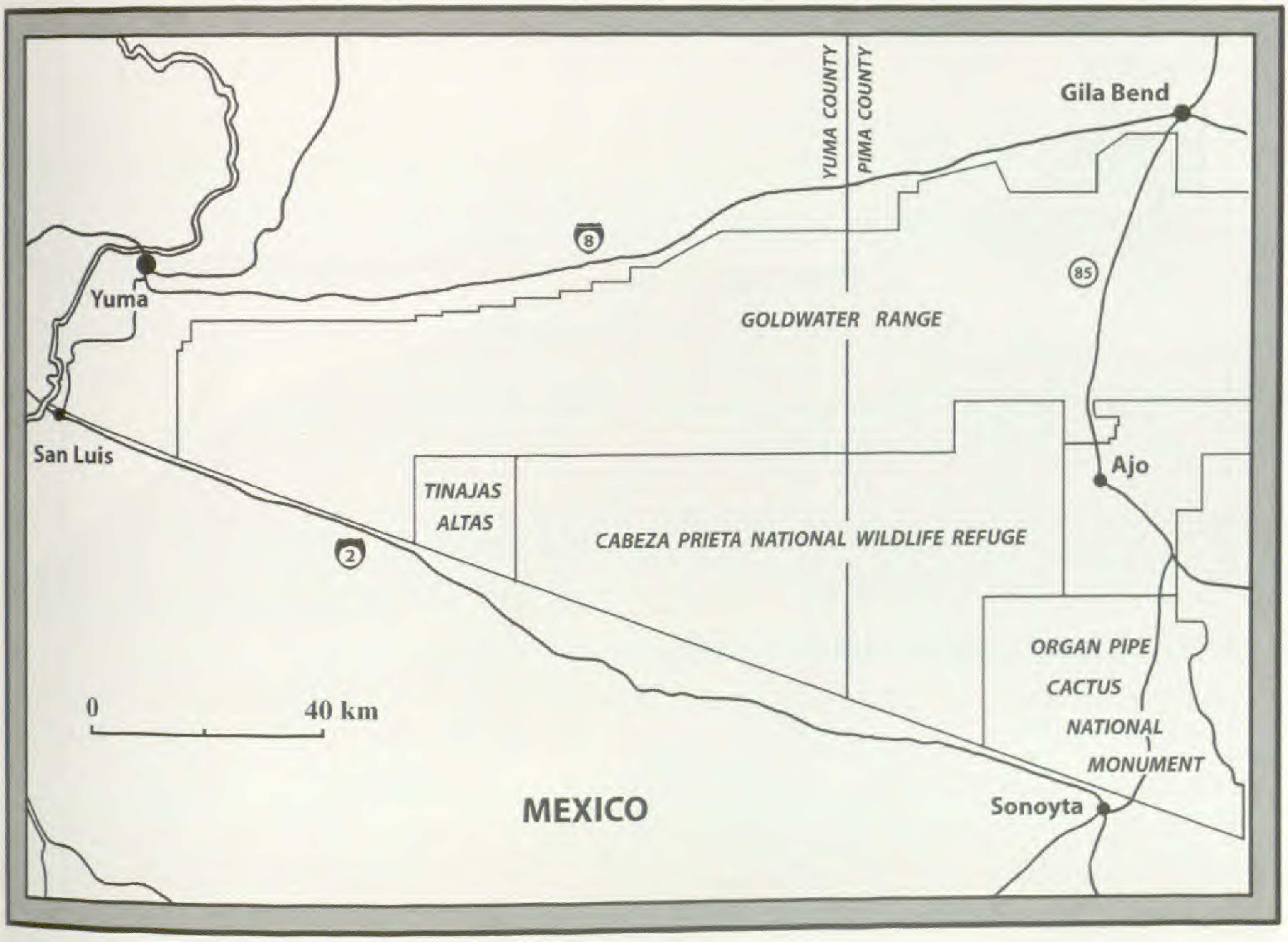
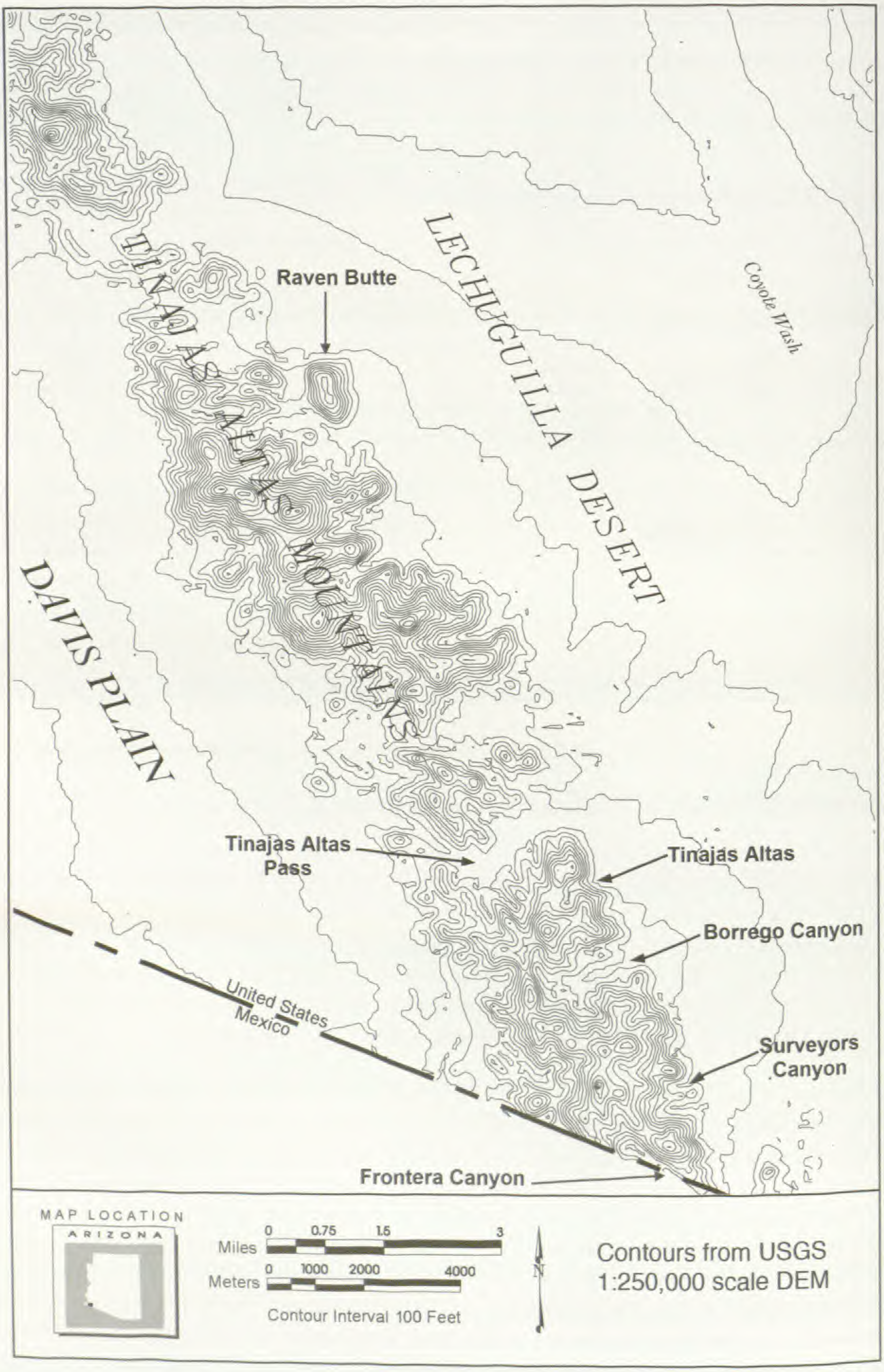


Fig. 6. Tinajas Altas Region, Cabeza Prieta National Wildlife Refuge, and adjacent areas, showing U.S. Interstate Highway 8 and Mexico Highway 2. Drafted by Cathy Moser Marlett.

indian Period (Malpais Period) that extends from 11,000 BCE or earlier to 8000 BCE. An Archaic Period extended from 8000 BCE to 800 CE. A major archaeological survey conducted at Tinajas Altas in 1998 found that "The archeological evidence ranges in age from the Middle Archaic period (5000–2000/1000 BCE) to the 1940s. … There is no evidence from the Paleoindian period" (Hartmann & Thurtle 2000: xxviii). However, archaeological evidence from the surrounding region dates from earlier times, and people likely utilized the site during the Early Archaic and Paleoindian periods (Adrianne G. Rankin, personal communication 2008; Altschul & Rankin 2008; Carpenter et al. 2008). At Tinajas Altas "Prehistoric evidence points to dominant use in the Ceramic period (ca. 800–1850 CE) by the Patayan, those enigmatic gatherers/hunters/farmers who occupied a vast area centered on southwest Arizona and southeast California" (Hartmann & Thurtle 2001: 512). Evidence from the historic period points to use by Hia C'ed O'odham (Hartmann & Thurtle 2001; Hartmann et al. 2007). A Hia C'ed O'odham camp, known as *O'ovak*, was once located on the Mesa del Muerto, the terrace to the east of the tanks (Ahlstrom & Lascaux 2000: 6). A trail used by Cocopahs traveling between the Colorado River delta and the lower Gila River valley intersected Tinajas Altas (Broyles et al. 2012), and an extensive network of foot trails crisscrossed the region allowing trade and travel at least as far as the Pacific Ocean, Colorado Plateau, and interior of Mexico (Becker & Altschul 2008; Broyles et al. 2012). Modern Native American cultural affiliations with Tinajas Altas involve as many as two dozen native nations (Fortier & Schaefer 2010).

Historically, the first Europeans known to have drunk from Tinajas Altas were Jacob Sedelmayr and his party in 1750. Although it has been speculated that Spanish explorer Melchior Díaz went there in 1540, evidence is lacking. Expeditions by Padre Eusebio Kino (1699, 1700, 1701, 1702) utilized other tinajas such as Heart, Cabeza Prieta, and Baker tanks. In 1774 and 1776 Juan Bautista de Anza did camp at Coyote Water, which he called Pozo de En Medio, but not at Tinajas Altas (Broyles et al. 2012). With discovery of gold in California in


TINAJAS ALTAS MOUNTAINS
LECHUGUILLA DESERT
DAVIS PLAIN
Coyote Wash
Raven Butte
Tinajas Altas Pass
Tinajas Altas
Borrego Canyon
Surveyors Canyon
Frontera Canyon
United States
Mexico
MAP LOCATION
ARIZONA
Miles 0 0.75 1.5 3
Meters 0 1000 2000 4000
Contour Interval 100 Feet
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Contours from USGS 1:250,000 scale DEM

FIG. 7. Tinajas Altas Mountains and adjacent areas, showing major collection sites. Cipriano Pass is the pass north of Tinajas Altas Pass. Drafted by Matt Schultz.

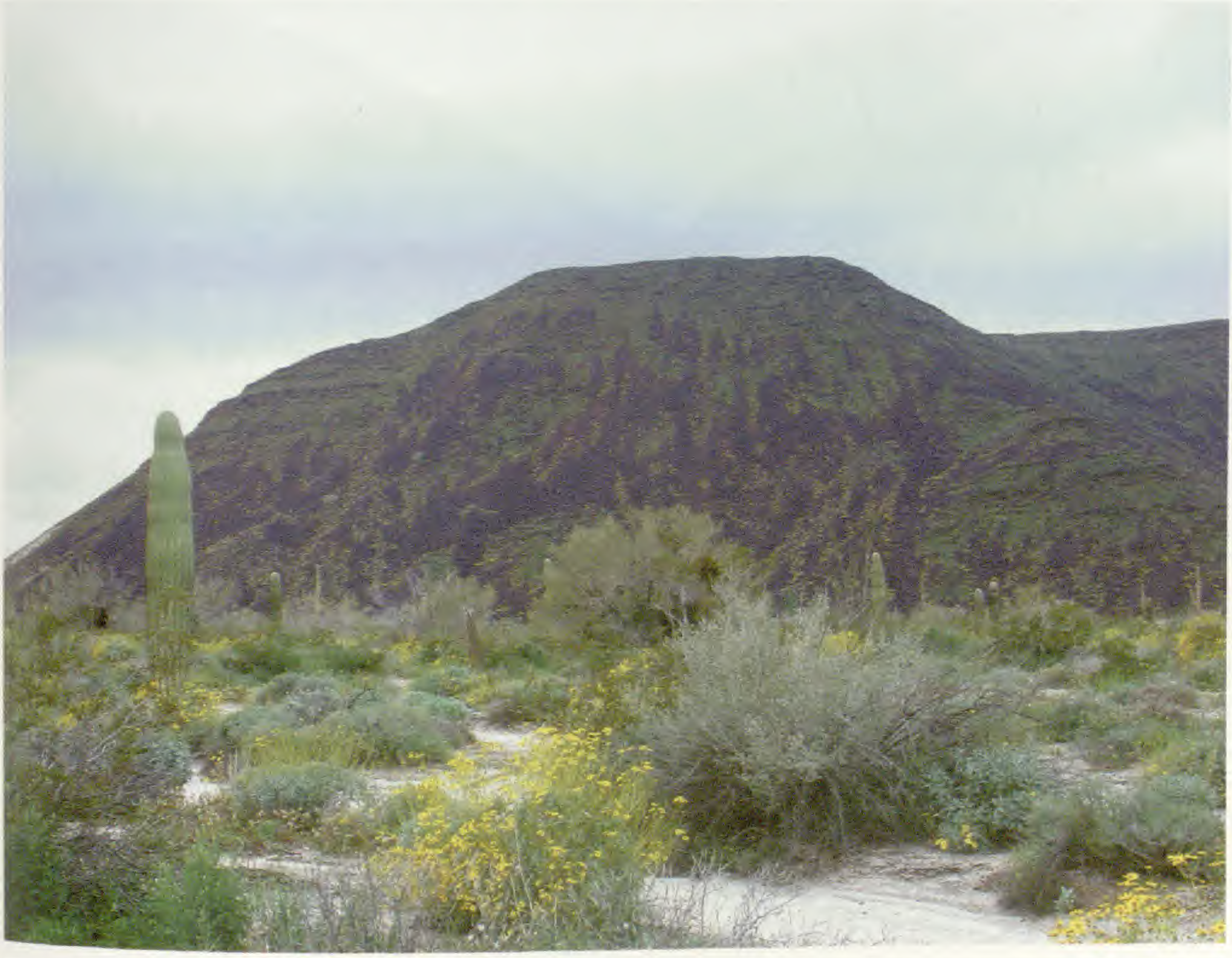

FIG. 8. Raven Butte, east-facing slope. Brittlebush (*Encelia farinosa*), desert lavender (*Hyptis albida*), and saguaro (*Carnegiea gigantea*). 27 April 2010. Photo by JM.

1848, a number of argonauts utilized the El Camino del Diablo route and sought water at Tinajas Altas. Following the Gadsden Purchase, which added Tinajas Altas to the United States in 1854, Tinajas Altas was visited by boundary surveyors (Emory 1987; Gaillard 1896; International Boundary Commission 1898), scientists (McGee 1901, 1905, 1906; Mearns 1907), speculators and geologists (Bailey 1963; Bryan 1925), hunters (Roosevelt 1920; Sheldon 1993), and naturalists and travelers (Lumholtz 1912; Pumpelly 1870, 1918). The area has long been unpopulated and unexploited commercially but popular among campers, tourists, and desert devotees.

MANAGEMENT AND STATUS

The boundaries for the current flora area coincide with those of the Tinajas Altas Addition to Cabeza Prieta National Wildlife Refuge as proposed by U.S. Fish and Wildlife Service (Master Plan Brochure 1970: map; U.S. Fish and Wildlife Service 1970a) and as incorporated within the refuge for a few months in 1975 by the Department of the Interior (Tunnicliff et al. 1986: 3.14). The boundaries extended the northern refuge boundary westward to a point about one mile west of Cipriano Pass and then southward to the US–Mexico border. The Tinajas Altas addition encompassed land sections in townships 12, 13, and 14S in range 17W and townships 12 and 13S in range 18W, totaling approximately 80,000 acres (Master Plan, Backup Volume 1970: 62; U.S. Fish & Wildlife Service 1970b) and including Raven Butte, the Tinajas Altas Mountains, and portions of the Lechuguilla Desert and Davis Plain, but the land was not congressionally included within the refuge. In turn because of its special biological, historical, archaeological, geological, and scenic values, the Bureau of Land Management in coordination with the Department of Defense subsequently designated much of the former addition as an Area of Critical Environmental Concern (ACEC) of irregular configuration comprising about 60,500 acres

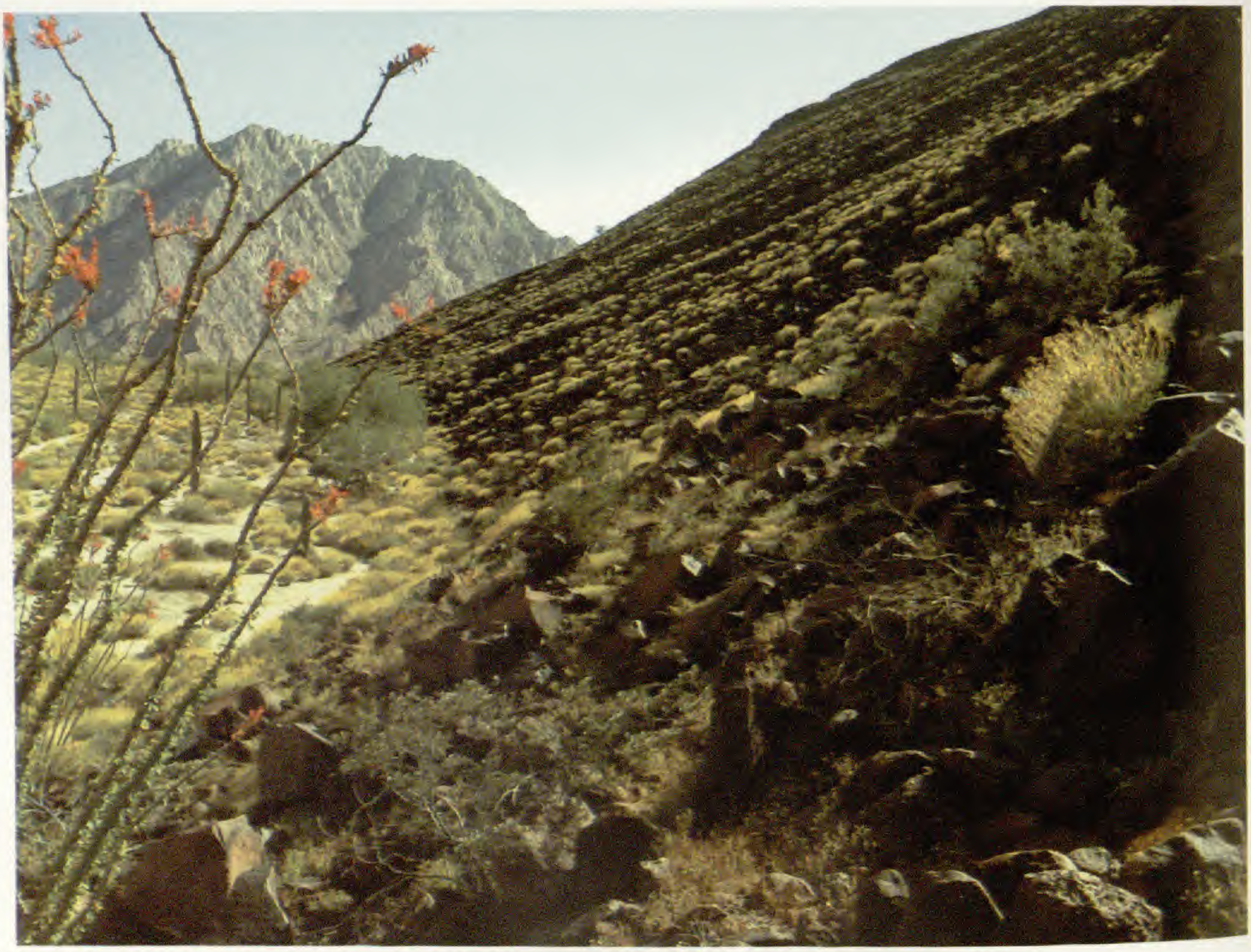

Fig. 9. Raven Butte, south-facing slope with brittlebush (*Encelia farinosa*) and ocotillo (*Fouquieria splendens*) in foreground. Granitic mountain in background is part of the Tinajas Altas Range. 27 April 2010. Photo by JM.

(Departments of the Air Force, Navy, and Interior 2006: 4.11), and later as a Special Natural Interest Area of comparable though not congruent boundaries (Range Management Department 2007).

Since 1941 Tinajas Altas has been managed as part of the expansive Barry M. Goldwater Range (BMGR, formerly known by several names including Luke Air Force Range). The U.S Marine Corps manages BMGR-West (which includes Tinajas Altas) and the U.S. Air Force manages BMGR-East. About 90% of the Range, including the Tinajas Altas region, remains largely unscathed by military pilot training and other national defense-related purposes. The Tinajas Altas region was managed by the Yuma Field Office of the Bureau of Land Management (BLM) in collaboration with the military until 2001. The intent of the Tinajas Altas Mountains Area of Critical Environmental Concern (ACEC) continues to be honored by the Marine Corps and the Tinajas Altas region has been designated as a Special Interest/Natural Area (see Departments of the Air Force, Navy, and Interior 2006). Other initiatives have been proposed to give the area special status. "In 1974 the Department of the Interior proposed adding to CPNWR [Cabeza Prieta National Wildlife Refuge] the 79,000 acres immediately adjacent to the Refuge's western boundary. ... This area, was actually added to the Refuge in a 1975 public land order…but was revoked several months later due to some technical flaws in the order" (Tunnicliff et al. 1986). Since 1998 citizens have variously proposed incorporating Tinajas Altas within a Sonoran Desert National Park and Preserve or a biosphere reserve, incorporating Tinajas Altas within the CPNWR, or designating it as a Traditional Cultural Property. A major management plan was conducted under the direction of the U.S. Marine Corps (Villarreal et al. 2011). Special designation, stricter regulations, increased staffing, and heightened management attention may be required to surmount expanding tourism, recreation, military exercises, and illegal activities such as smuggling and ensuing law enforcement. Conservation of plants and wildlife and protection of cultural resources at Tinajas Altas are not only merited but necessary under existing stewardship laws.

PLACES

Information for the place names is based in part on the regional gazetteer by Broyles et al. (1997, 2007), which was based on maps and other sources using NAD 27 datum.

Borrego Canyon. A major canyon in the southern part of the Tinajas Altas Mountains. The canyon mouth is at 32°17'58"N, 114°02'25"W, 1240 ft. Borrego Tank is in the canyon at 32°17'07"N, 114°03'03"W, 1590 ft.

Butler Mountains. This small, extremely arid, granitic range is 6 km (4 mi) west of the Tinajas Altas Mountains and adjacent to our core flora area. Its base is partially buried by drifting sands. It is a significant packrat fossil-midden study site (Van Devender 1990) and is named for Gurdon Montague Butler, dean of College of Mines at University of Arizona (1915–1940) and director of Arizona Bureau of Mines (1918–1940). Also known as Las Cuevitas on some older maps in recognition of the many eroded caves (tafoni) in the granitic rock. Summit is at 32°22'34"N, 114°12'23"W, 1169 ft.

El Camino del Diablo. This is the infamous, ancient route from Sonoyta to Yuma. It crosses the northern part of the Pinacate region, runs through Cabeza Prieta National Wildlife Refuge to Tinajas Altas, and ends at the Gila River. Also known as the Old Yuma-Caborca Trail, this was the route taken by some early Spanish explorers, by settlers from Mexico going to the San Diego, Los Angeles, and San Francisco areas, and by many forty-niners to the California goldfields (Fig. 1). The first motorcar trip across the Camino was in 1915 by Raphael Pumpelly (1918) and segments of it remain a primitive road.

The U.S. Fish & Wildlife Service (2008) provides the following summary:

> An historic route linking the northern frontier of Mexico and the Spanish settlements of California, El Camino del Diablo—Highway of the Devil—has witnessed centuries of intrepid travelers. Yet, a journey on El Camino has never been easy.
>
> Starting at Caborca, Sonora, Mexico, the 250-mile trip featured rest stops at Quitovac, Sonoyta, and Quitovaquito, before plunging headlong into the expanse of desolation that lent the trail its name. This stretch between flowing water on the Sonoyta River at Agua Dulce, and the rumor of stagnant water at Tinajas Altas, proved arduous to all, and deadly to many. …
>
> The 130-mile stretch from Sonoyta, Mexico, and what is now Yuma, Arizona, was a long ride through sere desert flats and across leg-wrenching lava malpais and drifting sand. In the cooler months, the trip might be only a slow plod, taking 3 to 10 days. Water might be found at Tule Tank or, if fortune really smiled, rain could deliver pools at Las Playas. In summer, temperatures here soar to 120 degrees F and people require two gallons of water a day just to survive. Waterholes and forage dry up. Yet, many set out anyway with the single-minded thought of reaching Tinajas Altas (High Tanks). Most of the graves line the last 30 miles of that leg; by one count 65 graves near Tinajas Altas proffered mute testimonial.

Cipriano Pass. A pass that separates Tinajas Altas Mountains from Gila Mountains, ca. 2 miles northwest of Raven Butte. Apparently named for Cipriano Ortega, a nineteenth century reformed bandit who may have driven cattle through this gap. It was also used by smugglers and called Smuggler Pass. 32°25'35"N, 114°09'34"W, ca. 1000 ft. Another Cipriano Pass is a gap in the southern Cipriano Hills, 3 mi N of Quitobaquito in Organ Pipe Cactus National Monument (Broyles et al. 2007).

Coyote Wash. The major axial arroyo draining the Lechuguilla Valley northward to the Gila River, though today it is blocked by the Mohawk Canal. It used to meet the Gila River at 32°41'32"N, 114°11'12"W.

Coyote Water. A waterhole on Coyote Wash 6 km northeast from Tinajas Altas, 32°19'59"N, 113°59'23"W, 960 ft. Historically important and known as Pozos en Medio (Broyles et al. 2012). Bryan (1925: 422) writes that Coyote Water

> lies in the axial stream of the valley, which is a channel filled with coarse sand about 100 feet wide and with soft banks about 3 feet high. The sand lies in great waves, which indicates the way in which the sand moves downstream during floods. The water remains in a cavity or scour depression in the hardpan that underlies the sand of the channel and is obtained by digging about 4 ft. A wooden signboard and the marks of coyote or human digging will guide the traveler in

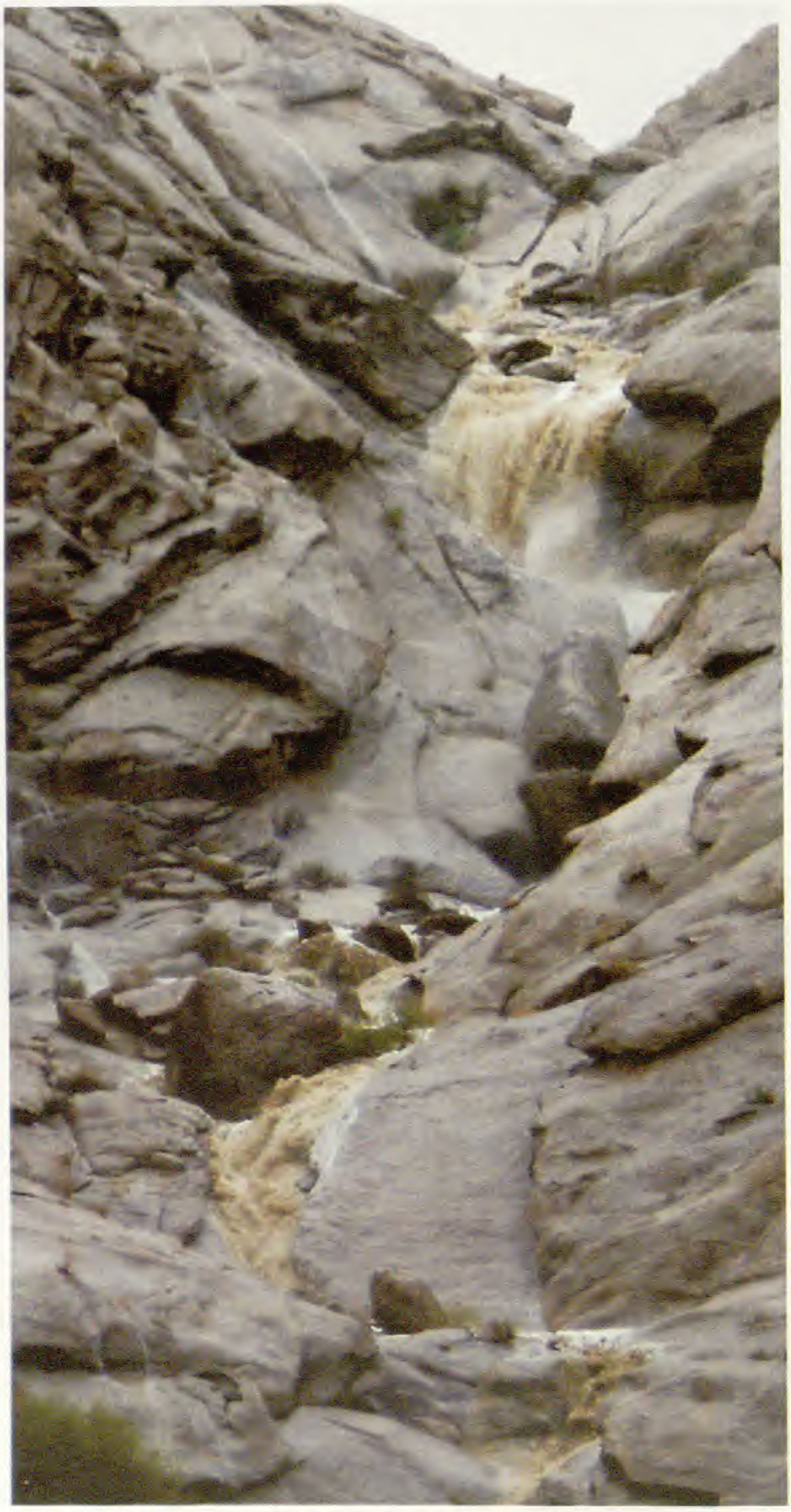

Fig. 10. A flash flood at Tinajas Altas, 13 Sep 2011. Photo by Scott Fischer, Arizona Game and Fish Department.

finding the exact spot. The water is small in amount and not very permanent and has a bad taste. The taste seems to be due to decaying plant roots.

Davis Plain. Sandy plain between the Butler and Tinajas Altas mountains. Named for geologist W. M. Davis (probably William Morris Davis, 1850–1934). The plain slopes gently to the southwest and supports the greatest number of ocotillos (*Fouquieria splendens*) in the study area. Ironwood (*Olneya tesota*) and blue palo verde (*Parkinsonia florida*) are widespread along the washes and runnels, although many of these trees died during the severe drought of 2003–2004. The approximate center of the plain is 32°26'15"N, 114°13'27"W, 900 ft.

Frontera Canyon. A large canyon draining the southern part of the Tinajas Altas Mountains. The canyon wash trends northwest from the vicinity of El Sahuaro (along Highway 2 in Sonora, Mexico) and becomes a canyon entering the mountains as it courses towards the high point in the range. The canyon wash crosses the international boundary, hence the name "frontera," coined in March 1998 by a group of hikers including Gayle Hartmann (personal communication, 1998). Some *Nolina bigelovii* in the canyon are unusually tall (see the species accounts). The canyon mouth is at 32°15'02"N, 114°01'31"W, 1100 ft.

High Tanks Gate. A seldom used name for a former border "crossing" along a dirt track in a low, broad pass at the international boundary between the Tinajas Altas Mountains on the west and the Sierra Lechuguilla on the east, 7.2 km (4.5 mi) south-southeast of Tinajas Altas and west of Border Marker 190. The name is a misnomer, since there was neither a gate nor a fence until 2008, when the site was obliterated by the tall, metal border barrier fence (Fig. 11). 32°15'08"N, 114°01'04"W, 1100 ft.

Lamb Tank. Named for young bighorn sheep, it is a subterranean artificial water tank built for wildlife in 1995 at the mouth of Surveyors Canyon, 32°16'26"N, 114°01'36"W, 1200 ft.

Lechuguilla Valley, Lechuguilla Desert. This is the arid valley-plain between the western margin of Cabeza Prieta Mountains and the eastern flank of the Tinajas Altas Mountains. This piedmont has minimal topographic relief as the broad plain slopes gently from the mountains to the axial wash, which drains the valley to the north by Coyote Wash and to the south by La Jolla Wash. The Camino del Diablo logically crosses the approximate divide for the northward and southward drainages since there is no arroyo cutting here. *Lechuguilla* is a common name in Mexico for agave, here *Agave deserti*.

Mesa del Muerto, Mesa of the Dead. This small mesa is named for the graves, once prevalent at the site, of travelers who perished on the trail. The mesa is a few hundred meters east of the Tinajas Altas. Access to the Tinajas and Tinajas Altas Canyon is from the parking area on the mesa. A wide trail leads from the mesa to the areas near the lower tinajas. McGee (1905) called it Mesita de los Muertos. 32°18'45"N, 114°02'53"W, 1160 ft.

Raven Butte. Distinctive basaltic butte abutting the east side of the Tinajas Altas Mountains (Figs. 8 and 9). The butte is possibly named for its raven-black color, but the Board of Geographic Names (U.S. Geological Survey 1987) implausibly states that it was named for the large number of relatively tame ravens found there in the early 1900s. Summit at 32°24'15"N, 114°06'33"W, 1773 ft.

Raven Butte Tank. A tinaja above huge granitic rocks in a canyon south of Raven Butte, at about 1220 ft.

Surveyors Canyon. Canyon in Tinajas Altas Mountains, 1.9 mi NNW of international boundary monument 190. Mouth at 32°16'30"N, 114'01'38"W, 1160 ft. **Surveyors Tank** in Surveyors Canyon is an intermittent natural tinaja used in 1890s by surveyors of the international boundary (International Boundary Commission 1898), 3.5 mi SSE of Tinajas Altas. It may equal Engineers Tank, shown on USGS 7.5 map at 32°16'20"N, 114°02'00"W, 1360 ft. A tank can be found there, but this site does not completely fulfill historic descriptions (see Sheldon 1993: 25, 91).

Tinajas Altas. These are the most significant tinajas or bedrock waterholes in the region. Dependable water made these large tinajas "renowned in the pioneer history of the district," according to Lumholtz (1912: 239, 396), though he was displeased in January 1910 to find "pieces of cast-off clothing, rusty tin cans, and other cheerless marks of human occupancy."

There are nine sets of intermittent and perennial pools that hold at least 77,664 liters (22,000 gallons) when full (Broyles 1996; Broyles et al. 2007). An arroyo from a hanging valley (Tinajas Altas Canyon) in these granitic mountains downcuts steeply through joint fractures to scour and pluck a staircase of pools. Prehistoric people were camping and variously using the area for millennia (Hartmann & Thurtle 2001). Although these waterholes are generally regarded as permanent, at times they have gone dry or nearly so and Broyles (1996: 491) informs us that "even the stalwart Tinajas Altas were virtually dry in the summer of 1905 (McGee 1905, 1906), June 1946 and winter 1957 (CPNWR files)." McGee (1906: 722) wrote, "The supply has been deemed unfailing; though singularly enough the water was practically exhausted in the summer following the exceptionally wet winter and spring of 1905, seemingly for the reason that the unusually prolonged and gentle precipitation served rather to fill the tinajas with sand than to sweep them clean and leave them brimming, as do the ordinary rains of the region." In fact, the lack of wetland plants (except *Typha domingensis*) at these tinajas probably is due to the scouring effect of flash floods and the lack of soil at the margins of the waterholes.

> Many wayfarers arrived to find the lower tinajas dry. … Perilously, they clambered up steep cliffs to retrieve mere bucketfuls for themselves and their struggling animals. Some victims, finding the bottom tanks dry, and unable to feebly

> claw their way up the steep cliffs, perished within a few yards of life-sustaining water. From Tinajas Altas the trail forked, and weary travelers and their exhausted livestock struggled toward the Gila or Colorado Rivers, which promised unlimited water, shade, and forage. Stronger parties swung west through the Yuma Desert directly to Yuma Crossing. More cautious travelers took the northern route from Tinajas Altas, skirting the eastern edge of the Gila Mountains to the Gila River, and then followed it to the Colorado River confluence upstream from Yuma. (U.S. Fish & Wildlife Service 2008.)

Broyles et al. (2007: 671) reported that the O'odham name is "'Ó'ovak or O'o Voopod ('where the arrows were shot'). Lumholtz reports a legend that two O'odham shot arrows from opposite sides of the mountain's spine. One's arrows cleared the mountain; the other's fell short and made holes in the mountains that became the tinajas. Fillman Bell [personal communication to Bill Broyles, 1987] asserts that 'O'ovak means 'a drawing hole', or 'place where moisture is gathered.' Also historically transcribed as Oo'oo'woopa ('where the arrows lie down')." Lowermost tank at 32°18'42"N, 114°03'02"W, 1200 ft.

Tinajas Altas Canyon. This hanging canyon or valley (Fig. 12), also described as the "upper canyon" or "high canyon-valley," leads southwestward above the uppermost tinaja (Fig. 13). This canyon system feeds into the tinajas. There is a surprising rich flora and a scattering, or interrupted small gallery, of xeroriparian large shrub/small tree desert legumes—ironwood (*Olneya tesota*), foothill palo verde (*Parkinsonia microphylla*), and catclaw acacia (*Senegalia greggii*). The canyon bottom just above the uppermost of the waterholes of Tinajas Altas is 32°18'41"N, 114°03'11"W, 1520 ft.

This high canyon is also known as the Upland Valley (Bryan 1925). Hartmann and Thurtle (2001), however, use "Tinajas Altas Canyon" for the large arroyo or entrenchment leading east from the lowermost tinaja into the Lechuguilla Desert.

Tinajas Altas Mountains. The north-south trending granitic range between the Gila Mountains to the north and Cerro Pinto to the south in Sonora. The summit is 32°16'24"N, 114°02'45"W, 2764 ft.

These mountains are described as "Rugged, but not very lofty…although the overall trend of the Tinajas Altas Mountains is straight, the topographic fronts of the mountains are generally very embayed and sinuous….The mountain slopes meet a nearly flat desert floor at a sharp angle, except where major channels exit from the mountain. Very steep, embayed topography with minimal colluvial cover indicates that erosion of the mountain fronts has had a long time to operate in the absence of renewed tectonic activity (Bryan 1925; Bull 1973). Erosion is facilitated by uncommon but intense rainfall and runoff, steep slopes, and sparse vegetation cover" (Biggs & Demsey 2000: 27).

Tinajas Altas Pass. Gap in the Tinajas Altas Mountains, 1.8 km northwest of Tinajas Altas. A primitive road through the pass leads northwest along the west side of the Gila Mountains, passing Fortuna Mine and ending at Yuma. To the east the road joins the main Camino del Diablo. 32°19'19"N, 114°03'48"W, 1130 ft, at the approximate highest point on the road.

BOTANIZING AT TINAJAS ALTAS, RICHARD FELGER

The plant life molded into the spectacular scenery at Tinajas Altas fits easily into Forrest Shreve's (1951) concept of Lower Colorado Valley subdivision of the Sonoran Desert. During the usual drought conditions you won't see much in the way of greenery and even the creosotebushes (*Larrea divaricata*) may be dried up, but go there after a generous rainy time and there is a richness of flowers, greenery, buzzing insects, birds, and other creatures. For example, in late October 2004, following hurricane-fringe rains, there was abundant greenery and a full complement of summer-season annuals (ephemerals) as well as the first winter-spring annuals. At the same time all around the Tinajas Altas little red-spotted toads (*Bufo* (*Anaxyrus*) *punctatus*) had just lost their tails and were stepping out into the dry world.

I had done considerable fieldwork in southwestern Arizona and northwestern Sonora just across the border from the Tinajas Altas, but had only a vague idea of the historically important waterholes before I visited the place. I had been botanizing in Organ Pipe Cactus National Monument and Cabeza Prieta National Wildlife Refuge for some time, and finally, in February 1990, I camped in the Tinajas Altas Mountains. The intact vegetation nestled among steep sculptured granite was intriguing. An extensive trip across Cabeza Prieta to

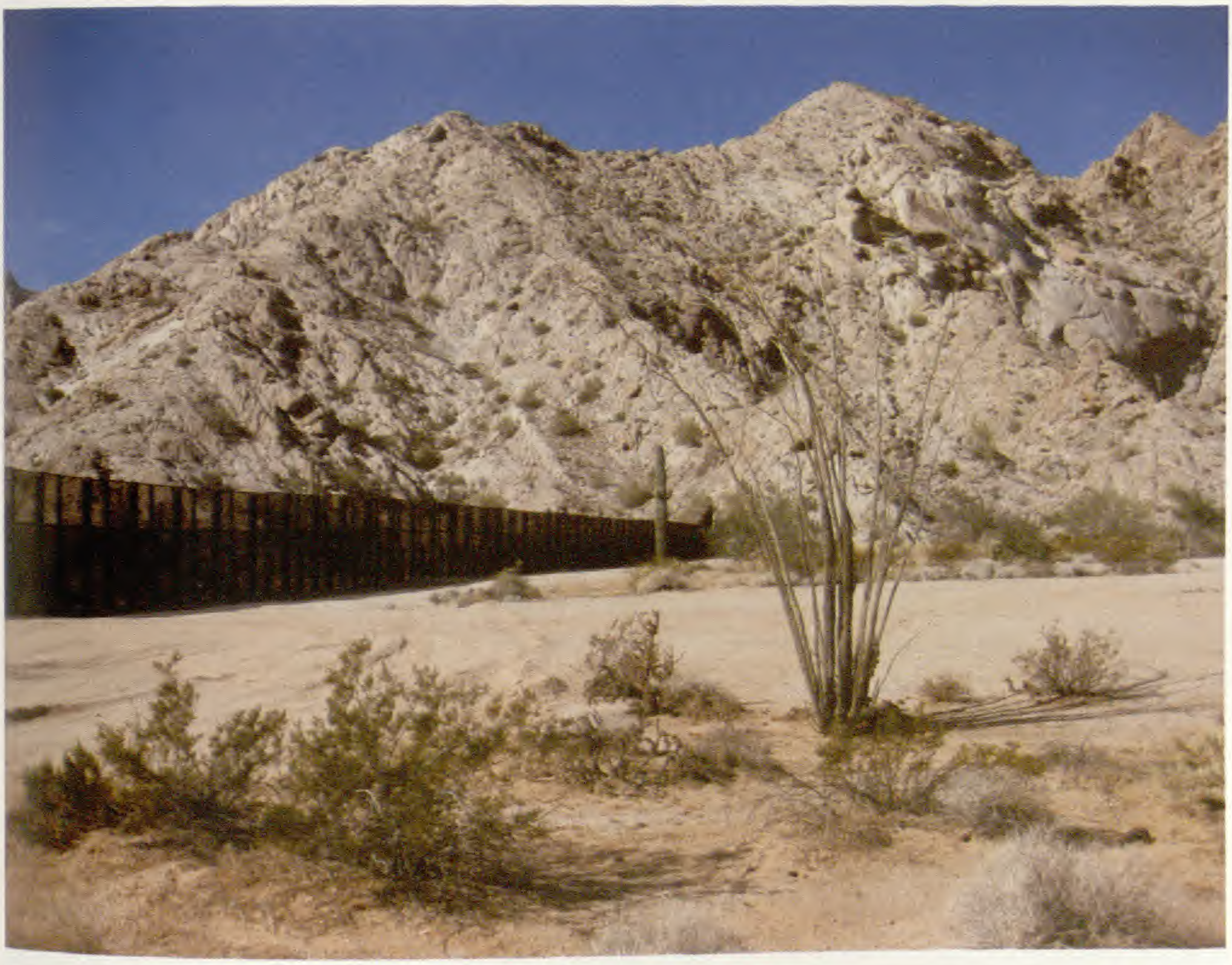

Fig. 11. Tinajas Altas Mountains at the U.S.–Mexico border, looking westward. The newly constructed border fence at the site of the former High Tanks Gate. Creosotebush (*Larrea divaricata*) and ocotillo (*Fouquieria splendens*) in foreground. 22 November 2008. Photo by RSF.

the Tinajas Altas Mountains in June 1992 sparked my interest. I was privileged to accompany Bill Broyles for a six-day field trip in Cabeza Prieta and the Tinajas Altas Mountains. It was the second week of June and I expected unbearable temperatures, but it was just wonderfully warm and we had plenty of water and time for good hikes, and of course botanical exploration. We saw no one else the whole time, except the morning of the first day when a van with Cabeza Prieta workers passed us on the road at the east end of the refuge. The rains had been generous that spring. New growth of creosotebushes encroaching narrow roads was full of fuzzy white fruits. I was surprised to see the vegetation so lush and dense, being that the annual rainfall is so scanty and June is the hottest, driest month—a day under 37.8°C (100°F) is rare.

My first really significant botanical reconnaissance of the Tinajas Altas region was in March 1998. In just a few days, Luke Evans and I covered much of the region. Luke was verifying data for a revision of the Dry Borders gazetteer (Broyles et al. 2007). I had heard of giant tree nolinas (*Nolina bigelovii*, see species accounts) growing in the place Gayle Hartmann and friends named Frontera Canyon and Luke knew how to get there.

18 March 1998. We leave Tinajas Altas early in the morning and head for the border on the old Surveyors Tank Road along the east side of the Tinajas Altas Mountains. The road is a rough dirt track to the border at a place sometimes called "High Tanks Gate," although there is not a gate or even a fence. The road continues into Sonora, Mexico, where there has been considerable vehicle traffic that does not continue northward—the vehicle tracks are from drug or people smugglers not driving into the U.S. We lock up the vehicle on the U.S. side (I hope it will be here when we get back) and walk several hundred meters into Sonora, going south and then westward, skirting the southernmost tip of the mountain. We see where a U.S. border patrol helicopter has marked the sand with landing skids on the dirt road on the Mexico side. They come back later to look for foot-

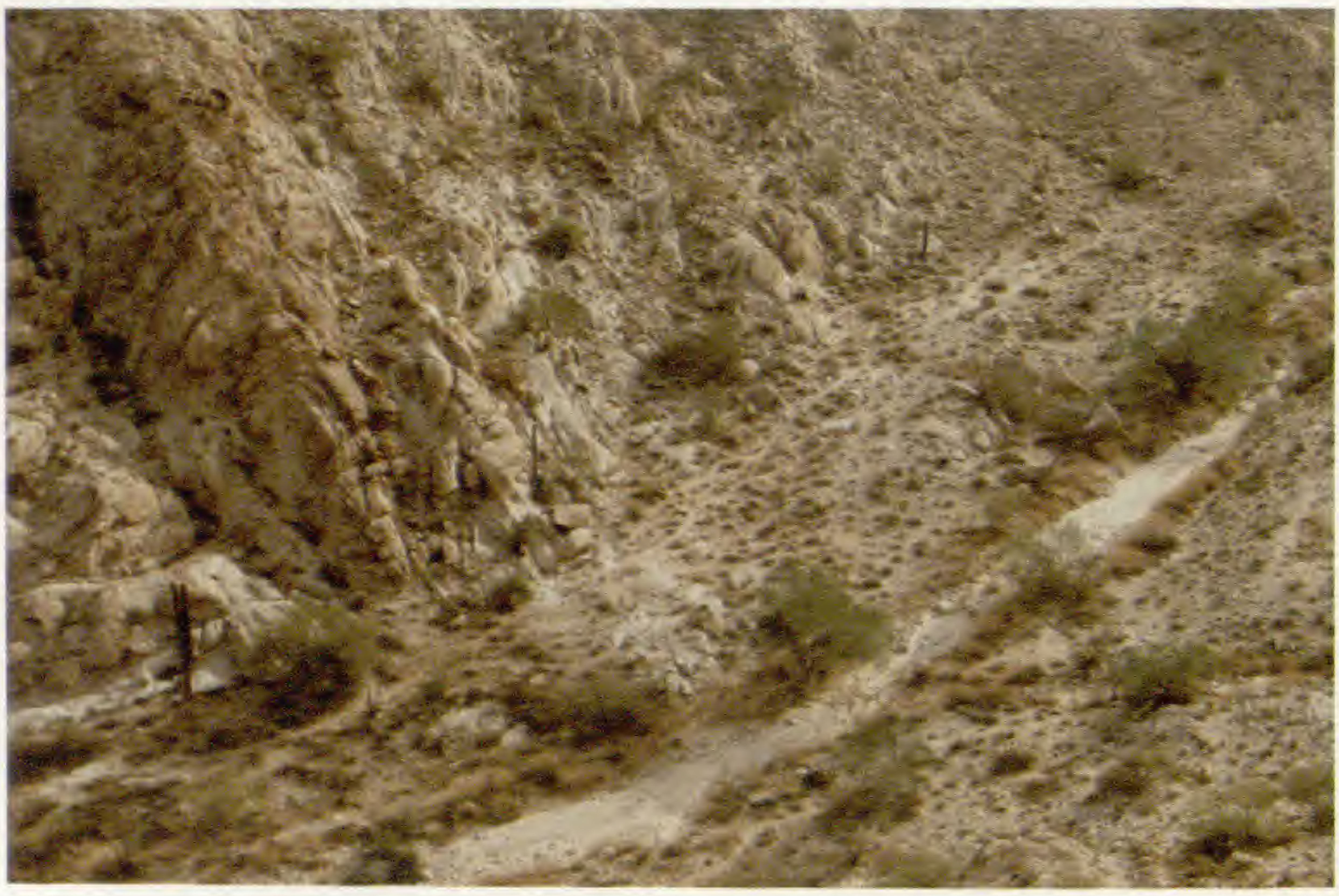

Fig. 12. Tinajas Altas Mountains, looking down at Tinajas Altas Canyon near the uppermost tinaja. Note bighorn trails. 21 November 2008. Photo by RSF.

prints, indicating illegal border crossers. Mexico Highway 2, the only road in Mexico linking mainland Mexico with the Baja California Peninsula, is only a few kilometers to the south. After walking around the southern toe of the mountain we head northward into the large, main canyon draining southward from the Tinajas Altas peaks, soon crossing back into the U.S. There are no border markers or a fence here and we are soon in Frontera Canyon heading northward. This canyon is a "dead end" leading into steep, near impassible steep, rock slopes.

We come across recent trash and "El Yori 1998," the name of a popular Mexican rock band, freshly carved into an overhanging ironwood branch. We hike up the canyon, up and over huge boulders making up the canyon floor, and I record the plant species encountered. We soon find the *Nolina bigelovii* giants—the biggest ones I have ever seen (see the species accounts). We record GPS readings, measure the nolinas, and I collect specimens of the more interesting plants, putting them in plastic bags to prevent them from wilting, to be pressed later. Luke carries out yesterday's trash. Was it left by border crossers or smugglers waiting for nightfall?

Later in the day we are back at Tinajas Altas and climb up above the tanks. From the ridge along an indistinct trail I look down onto ironwood (*Olneya tesota*) and palo verde trees (*Parkinsonia microphylla*) sparsely strung along the bottom of a high hidden canyon, which we are calling Tinajas Altas Canyon (Fig. 12). The place looks eerily pristine, without human influence. The steep slopes across the canyon are marked with switchback animal trails, like the kind you see where there are too many cattle. No cows here, these are from desert bighorns (*Ovis canadensis mexicana*). I remind myself that with all this tinaja water, people have been here since Ice Age times and must have had impacts on the place. Surprisingly, I find no more than several mesquites (*Prosopis glandulosa*) along the canyon bottom. We were lucky that it is a "good" spring and the vegetation is luxurious. By the end of the day my backpack is crammed full of plant specimens in Ziploc plastic bags, each marked with a piece of paper keyed to notes in my pocket notebook. That night and early the next morning I fill the plant presses.

On other occasions it is so dry that even creosotebush leaves are shriveled, such as a November 2002 field trip with Curtis McCasland, then ecologist at Cabeza Prieta National Wildlife Refuge and later manager of the Refuge. Returning with Curt on October 24, 2004, the margins of Coyote Wash, at Coyote Water along the bottom of Lechuguilla Valley, are like a jungle. The hard damp vertical banks, about 1 m high, are shaded in greenery and the soil held together with a carpet-like biological crust of blue-green algae, liverworts, soil lichens, green mosses and the like (*see* Belnap 2007; Rosentreter et al. 2007). I find "semi-wetland" plants such as *Ama-*

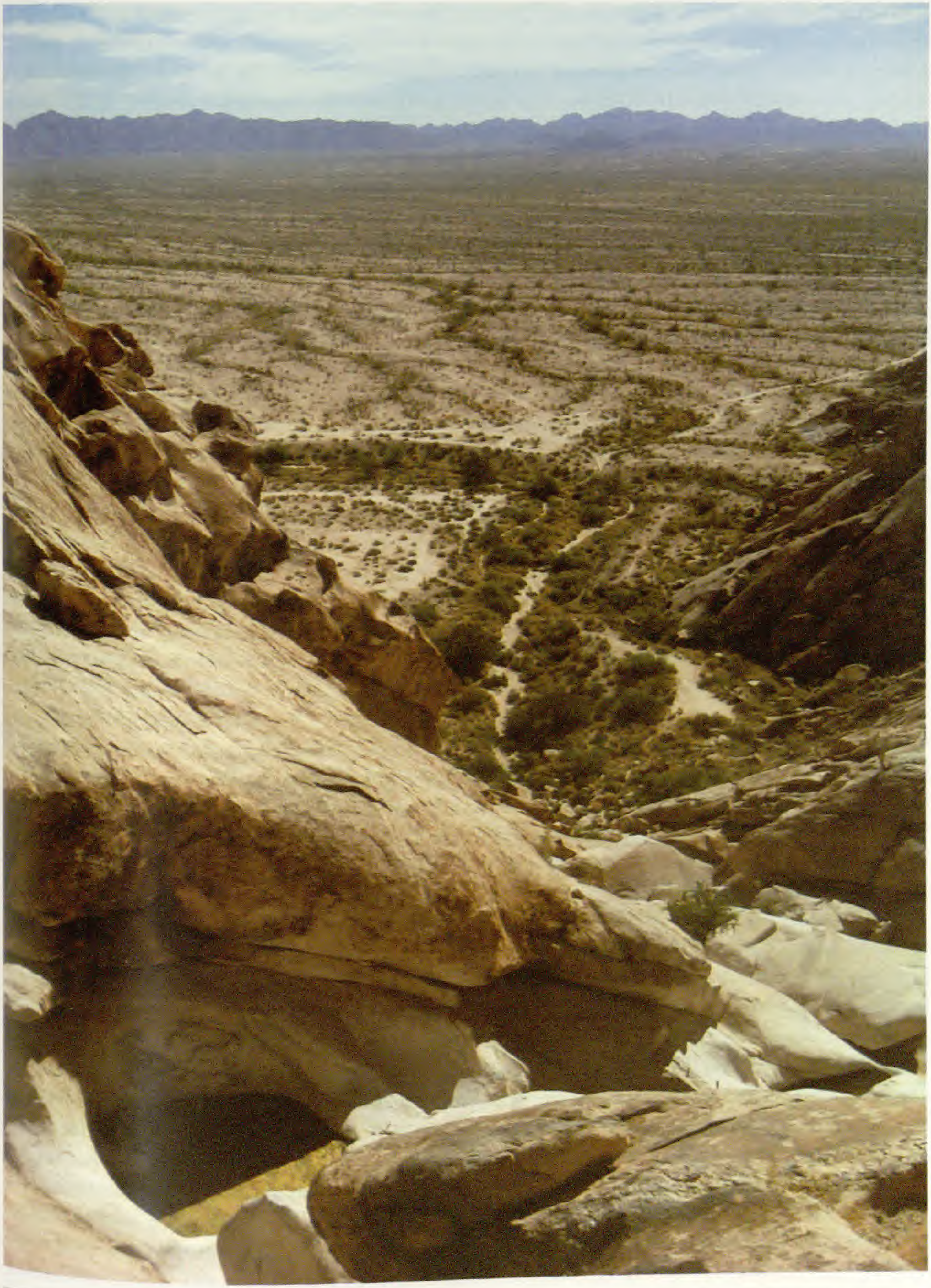

Fig. 13. Uppermost tank at Tinajas Altas, looking eastward across the Lechuguilla Valley with Cabeza Prieta Mountains in the background. 28 April 2010. Photo by JM.

ranthus crassipes and *Cyperus squarrosus* that I would not have expected, as well as robust annuals, some bigger than I have ever seen. Recent tropical depression storms soaked the place while it was still warm enough for the summer annuals to keep going or germinate and late enough in the year for the winter-spring annuals to get started. There is a full complement of summer annuals (ephemerals) such as *Amaranthus*, *Pectis*, and *Tidestromia*, as well as the first cool-season annuals such as *Oenothera* and *Plantago*. Green gallery walls on both sides of the wide wash are a tangle of honey mesquite (*Prosopis glandulosa*) to about 8 m tall with heavy trunks, catclaw acacia (*Senegalia greggii*), desert wolfberries (*Lycium fremontii*, *L. macrodon*, and *L. parishii*), brittlebush (*Encelia farinosa*), canyon ragweed (*Ambrosia ambrosioides*), and numerous other species. But ironwood is missing from this lowest part of the valley floor, the nearest ones a few kilometers away on the middle to upper bajada closer to the Tinajas Alas Mountains, and I don't have a good explanation for its absence.

Late afternoon we go to where the Camino del Diablo crosses the divide of the Lechuguilla Valley almost at the Mexican border. There is sheet flow here but no wash has formed, for it is here that the valley drains northward to form Coyote Wash, coursing towards the Gila River, and southward to form La Jolla Wash, coursing into the sands of the Gran Desierto (Broyles et al. 2007). It is humid and warm and an aromatic yellow carpet of desert chinchweed (*Pectis papposa*) and other summer annuals almost completely covers the ground between the creosotebushes, mesquites, lycium shrubs (*Lycium macrodon* and *L. parishii*), desert saltbushes (*Atriplex polycarpa*), white bursages (*Ambrosia dumosa*), canyon ragweeds, brittlebushes, and button encelias (*Encelia frutescens*). Half-grown sphinx-moth caterpillars graze on *Boerhavia* plants and there is a constant buzz of insects. The soil is glistening mud made solid by biological soil crust. Some of the annual desert daturas (*Datura discolor*) are shrub-like about one meter tall.

We turn around to go to Tinajas Altas to camp for the night. It is 5:55 and we have not passed another vehicle since entering the Goldwater Range south of I-8, although a border patrol vehicle is in front of us. They are on a jeep trail roaming around looking for illegal border-crossers on foot and in vehicles. Between the illegals and border patrol the desert floor is being crushed and eroded.

Soon after dark a 4-wheel-drive SUV shows up with four "herpers." They ask Curt if he knows where they might find rosy boas (*Lichanura trivirgata*) and head off with headlamps. They come back after an hour or so and report young red-spotted toads everywhere and one subadult female chuckwalla. I ask if they are collecting and they say, "we hardly do anymore." Later Curt says it's not against the law to collect most herps. They leave and the night is peaceful except for noisy mosquitoes. Bright lights to the northeast are from aerial flares in military maneuvers on the Goldwater Range.

The next morning, October 25, we climb nearly to the top of the Tinajas Altas Mountains, going way up past where Luke and I went in March 1998. Again I find only a very few mesquite trees along the high canyon above the tinajas. Barrel cacti are also scarce—we see only a few large ones on inaccessible cliff faces where bighorn sheep cannot reach them (see species accounts for *Ferocactus cylindraceus*).

During the day I see remains of about half a dozen rusty military ordinances (rocket motors and other remnants of military aerial gunnery training). A golden eagle tops a high ridge. About three-quarters of the way to the top we see a still-standing dead nolina and estimate the trunk to be 6 m tall. On north- and east-facing slopes the vegetation has become denser in places where there is enough soil. There are several more very large, downed and dead nolinas. Apparently the soil eroded away and they fell over. Perhaps they are the same age class as the Frontera Canyon giants. A bighorn sleeping-place in an eroded (tafone) cave is full of fresh, smelly bighorn droppings. Farther up I find a small, localized patch of desert spike-moss (*Selaginella arizonica*). We have not seen it elsewhere on the climb, although I would expect it since this spike-moss is common in similar habitats elsewhere in these mountains. Has it been eliminated by bighorn sheep? I am somewhat surprised to find, apart from subtle increases in vegetation density, only minor elevational differences in the plant life from low- to high-elevation.

Before climbing down steep rough granitic rocks, I stop to look out across a vastness of desert silence. Dark xeroriparian ribbons writhe like double helices across the distant pale brown valley floor scratched only by the Camino del Diablo.

By 2008 the Tinajas Altas portion of the desert had started to make a gradual recovery due to reduced illegal border-crossing traffic, a result of multiple factors, including increased border patrol presence and an economic downturn in the U.S. By mid-year the U.S. Department of Homeland Security began building a 14-foot-high metal fence along the border (Fig. 11).

On 20 November 2008, Ben Wilder and I drive from Tucson to Tinajas Altas, arriving at 1:40 pm. Driving south from I-8 on the wide graded road we pass numerous huge trucks engaged in the border fence construction. They have cleared what appears to be hundreds of acres on the valley floor northeast of Tinajas Altas as a headquarters and staging area. Looks like a moonscape.

The lowermost Tinajas Altas tank has water swarming with mosquito larvae and multitudes of tiny, young red-spotted toads are all about. A sprawling *Boerhavia coccinea* is same plant among rocks in front of the tinaja that I have seen on every visit. Bighorn scats everywhere, plus a small quantity of larger scats that appear to be from a burro (donkey). The vegetation is somewhat dried up—it has not rained for quite a while. Ben climbs to a lower-middle tinaja, tank #4, and finds numerous tadpoles and the elusive cattail (*Typha domingensis*, see species accounts). I investigate the lower slopes and adjacent areas for worthwhile records. The large blue palo verde (*Parkinsonia florida*) in the canyon wash east of tinajas is gone: it was here in 2004. We camp on the Mesa del Muerto east of the tinajas and the roar from border-fence construction trucks goes on all night.

The next morning we climb the steep hanging canyon just north of the tinajas. From the ridge/saddle looking down at Tinajas Altas Canyon we see the numerous bighorn switchback trails on the lower slope across the canyon, leading into the upper tinajas (Fig. 12). In the canyon bottom wash leading to the uppermost tinajas we find the sand pocked with bighorn tracks and their scats are everywhere. Some saguaros (*Carnegiea gigantea*) about 1 to 1.5 m tall have been bashed in by bighorn seeking moisture (Fig. 14).

On the morning of the 22nd we drive south from the Tinajas Altas area along a wide, new graded road approximately along the old Surveyors Tank Road to the new border fence at the High Tanks Gate area (Fig. 11). The desert along the border is scraped bare. The fence stops at the steep granitic mountain, providing a place to walk to and from Mexico.

Returning northward, about half way to Tinajas Altas, the road cross two large washes coursing eastward from mountain canyons. These washes have their margins jammed full of dense green vegetation and a blaze of flowers, apparently the result of a recent flash flood, including yellow of brittlebush (*Encelia farinosa*) and red of hummingbird bush (*Justicia californica*), as well as *Ambrosia dumosa, A. ilicifolia, Bebbia juncea, Brandegea bigelovii, Datura discolor, Funastrum hartwegii, Horsfordia alata, Lycium andersonii, L. brevipes, L. fremontii, L. macrodon, Hyptis albida, Larrea divaricata, Olneya tesota, Parkinsonia florida*, and *Senegalia greggii* (Fig. 15). The adjacent desert vegetation is dry and drought-stressed.

We turn east on a wide new road past a new mountain of sand being worked by bulldozers for making cement for border fence posts. The border fence construction site is off-limits. We turn back and head for Tucson.

On March 25 to 29, 2010, I accompany Bill Broyles and Joan Scott on a field trip across the Camino del Diablo, from Organ Pipe Cactus National Monument through Cabeza Prieta National Wildlife Refuge to the Tinajas Altas region. At the Refuge offices in Ajo we see Curt McCasland, the Refuge manager. He tells us the area along the Camino del Diablo in the Refuge is not really wilderness anymore: emergency stations (with survival water for border crossers) are every 5 miles and there is a heavy presence of Border Patrol. In camp that night we meet up with the rest of our party. There are six of us: Bill Broyles and his wife Joan Scott, a wildlife expert retired from the Arizona Department of Game and Fish, Luke Evans, an environmental consultant and regional scholar, David Taylor, a Guggenheim fellow from New Mexico State University who is re-photographing all the border monuments from Texas to California, and Richard Laugharn, a fine art photographer from Phoenix who has been tracking specific desert plants year after year. The last two days are spent in the Tinajas Altas region.

On the 28th, Richard Laugharn and I stop at the Camino crossing of the Lechuguilla Valley bottom and explore the mini-jungle of mesquites at the beginning (southern limit) of Coyote Wash. The mesquites, mostly 3–4(–5) m tall, are nearly impenetrable. I am looking for *Teucrium glandulosum*, which I had previously found

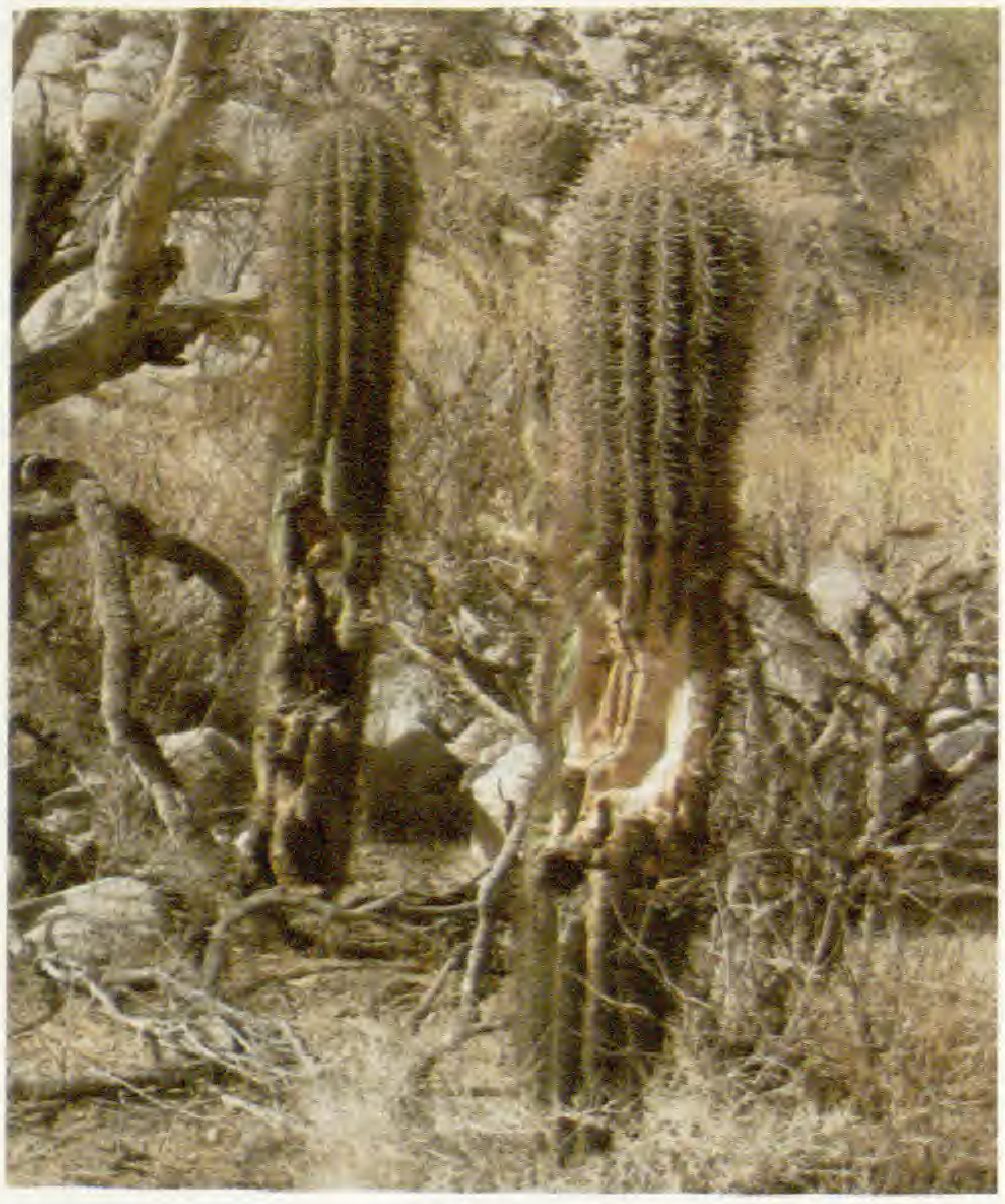

Fig. 14. Saguaros (*Carnegiea gigantea*) damaged by bighorn. Tinajas Altas Canyon above the tinajas. 21 November 2008. Photo by RSF.

but only as a dry skeleton, but there was no sign of it. The ground is mostly covered by the invasive Sahara mustard (*Brassica tournefortii*) of incredible size variation. The soil is still damp from last rains and where the ground is not covered by ephemerals I see a continuous blackish surface of microphytic crust with blue greens and bacteria (see Belnap 2007; Rosentreter et al. 2008). Milkweed vines (*Funastrum hartwegii*) interlace the jungle, reaching into the tops of the mesquites. Inside the jungle the air is hot, humid, and still. *Lactuca serriola* and *Sphaeralcea emoryi* are new records for the Tinajas Altas region. Later in the day I am botanizing around Tinajas Altas. Near full moon and using a headlamp I press the day's specimens, all in good shape in Ziploc plastic bags in the frig in the back of Luke's pickup.

On the March 29, after a quick breakfast, I go with Luke Evans in his Toyota pickup. He has a laptop floor-mounted in the cab with topo maps on the ready and other techno conveniences. We drive south and then westward into Surveyors Tank Canyon, to a small parking area near the mouth of canyon at Lamb Tank, an elaborate artificial buried water catchment leading into a small cement water tank for bighorn sheep. Bighorn scats are abundant as well as Sahara mustard. The tank is full and swarming with honeybees, which we had not seen elsewhere on the trip. Surveyors Tank is further up the canyon and is entirely natural. There are bedrock grinding holes near the tinaja. We do not see barrel cacti and agaves are surprisingly few, probably due to bighorn sheep—their scats are numerous.

In the late morning we drive back north to our camp near Tinajas Altas, pack up, and head north. We take a dirt track west from the Camino into a large canyon in the granitic mountains. We park at the end of the road and hike up a canyon with huge granitic rocks. Like most canyon sites in these mountains, there are about two-dozen conspicuous major perennials and more than two-dozen winter-spring annuals. I saw only one small barrel cactus (*Ferocactus cylindraceus*).

Leaving for Tucson in the early afternoon, I am riding with Bill and Joan. Going north on the graded dirt road along the sandy Lechuguilla Valley to Wellton I see large plants of Sahara mustard all along the roadside but no buffelgrass. We pass spectacular ocotillo "forests" along the sandy valley floor, the stems red tipped in full flower. We stop for cold drinks at a convenience store in Wellton. A long line of farm workers bused in daily from San Luis, Sonora, are spending money on junk food and pop. In the back seat I am pressing plants all the way from Wellton to Tucson.

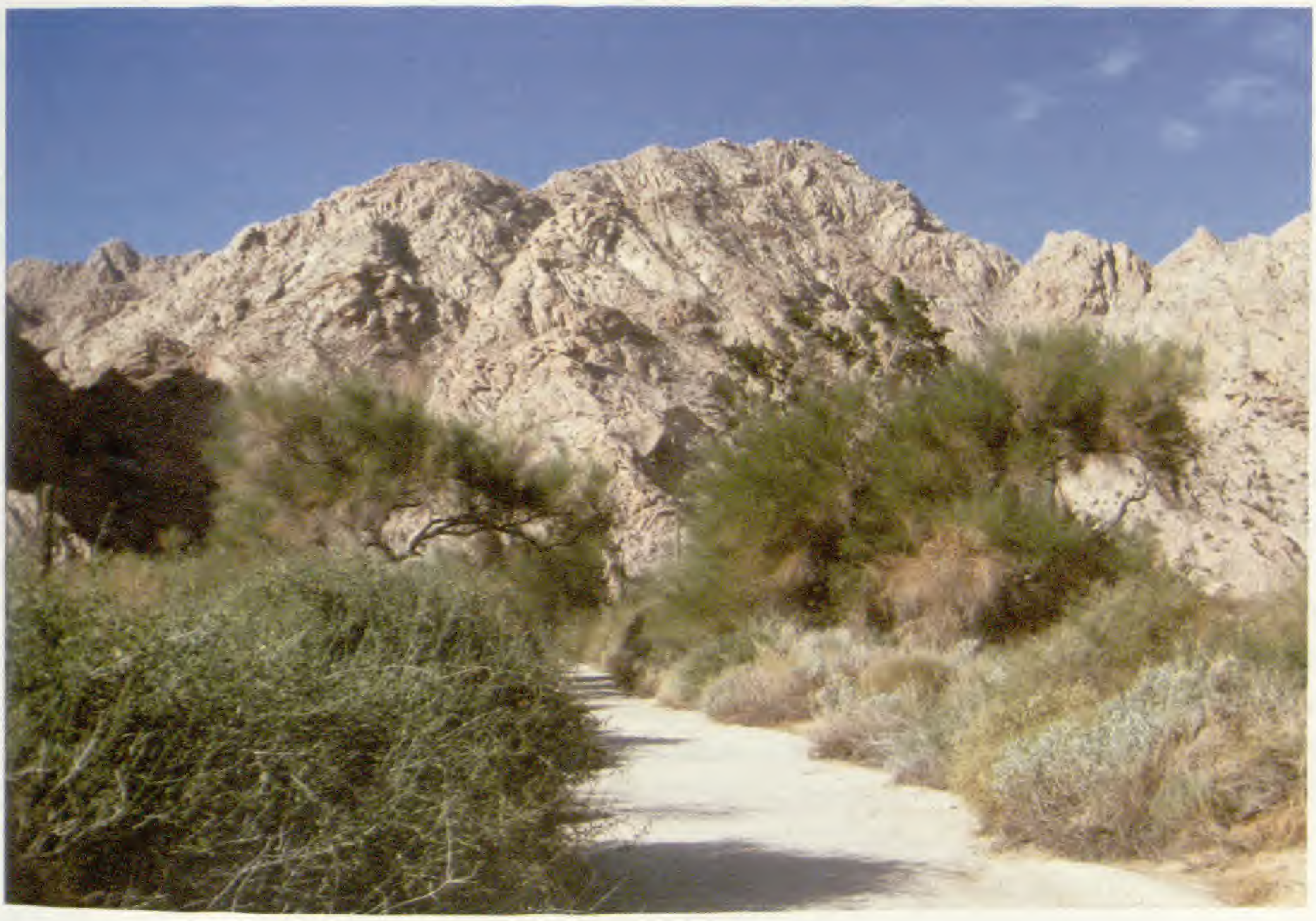

Fig. 15. A major wash from the east side of the Tinajas Altas Mountains. Desert hummingbird-bush (*Justicia californica*), brittlebush (*Encelia farinosa*), sweetbush (*Bebbia juncea*), Anderson wolfberry (*Lycium andersonii, Felger 08-196*), and blue palo verde (*Parkinsonia florida*) along the wash. 21 November 2008. Photo by RSF.

DEEP HISTORY AT TINAJAS ALTAS, TOM VAN DEVENDER

Deserts are notoriously bad places for preservation of fossils. In wetter climes plant materials and dead animals fall into water, are quickly buried, and minerals may replace their organic fabric. Yet the Tinajas Altas Mountains, in one of the most arid parts of North America, have one of the richest fossil records for Ice Age plants in the world. The humble packrat has collected and curated hundreds of species in the southwestern United States for more than 43,000 years. In 1962, Phil Wells, a plant ecologist, and Clive Jorgenson, a mammalogist, climbed the isolated, desolate Spotted Range on the Nevada Atomic Test Site. On the way down they entered a rock shelter to eat lunch, where they found a dark, organic mass full of twigs and seeds that Wells recognized as juniper and fecal pellets that Jorgenson knew were from packrats. It was the rich dark reddish-gold color of *amberat*, the caver's name for the shiny crystalline veneers of packrat urine on cave walls. Wells later radiocarbon-dated a piece of the deposit to more than 10,000 years ago. Wells named the deposits 'middens,' a term borrowed from archeologists referring to human garbage piles. The 1980s were a time of discovery—the Amber Rush had begun (Van Devender 2007). These studies are summarized in *Packrat Middens: The Last 40,000 Years of Biotic Change* (Betancourt et al. 1990).

Packrats (also called woodrats) are medium-sized rodents that carry plant and animal materials and other objects back to their houses or dens. In dry rock shelters some of this material on ledges or in crevices away from the main den deposit may become cemented with their urine into hard, dark organic middens (Betancourt et al. 1990). These deposits reflect many years of gradual accumulation of plant material collected within only about 30 m of the rock shelters, and are excellent for reconstructing past vegetation and climate.

In February of 1979, botanists Art Phillips and Barbara Phillips from the Museum of Northern Arizona were exploring the Tinajas Altas Mountains when they found a packrat midden in a canyon on the east side of the range, south-southeast of the famous 'high tanks' area. In March of 1980, I returned to the area in search of more middens and the promise of reconstructing the history of vegetation in a new area in the Sonoran Desert.

On the map, the most direct route was from Interstate 8 east of Yuma down the west side of the Gila Mountains to the old Fortuna Mine and southward through Tinajas Altas Pass. This was a real adventure with stark, beautiful landscapes and wondrous spring wildflowers. But it was a slow trip crossing the myriad of arroyos draining the mountains and a strain on my Volkswagen Beetle and kidneys. Eventually the Tinajas Altas were reached on the east side of the mountains where broad grussy arroyos (from grus, sand-like erosive material from granite) adorned with blooming chuparrosas (*Justicia californica*) drain white granite slopes. As we worked our way above the tanks, we spotted a coiled speckled rattlesnake (*Crotalus mitchelli*), a medium-sized rock dweller. This one was nearly white with black speckling—a perfect match for the pale granite. Looking eastward, the thin ribbon of the Camino del Diablo stretched to the horizon across the broad Lechuguilla Valley. Here the desertscrub is so sparse that the small desert trees are restricted to xeroriparian strips along washes in a sea of widely spaced diminutive creosotebush (*Larrea divaricata*) and white bursage (*Ambrosia dumosa*).

Ancient packrat middens proved to be common, resulting in a remarkable fossil record (Van Devender 1990). A total of 24 middens with 31 different stratigraphic units were found in 12 rock shelters (Table 3). Each discrete unit in a midden was numbered and analyzed separately. A total of 30 radiocarbon dates obtained on materials from 21 of the samples from 11 of the middens ranged in age from 245 to more than 43,000 ybp (radiocarbon years before 1950). An additional 12 dates obtained from nine samples from six middens from the nearby Butler Mountains ranged in age from 740 to 11,250 ybp. The Tinajas Altas and Butler Mountain samples also yielded abundant animal remains, including invertebrates (Hall et al. 1988, 1989, 1990) and small vertebrates (Van Devender & Mead 1978; Van Devender et al. 1983, 1991).

The radiocarbon-dated plant assemblages provide a detailed record of dramatic changes in geographic ranges of species and the succession from Ice Age woodlands to modern desertscrub. Prior to 11,000 years ago, in the middle and late Wisconsin, woodlands with single-leaf pinyon (*Pinus monophylla*), California juniper (*Juniperus californica*), Joshua tree (*Yucca brevifolia*), Mohave sage (*Salvia mohavensis*), and desert tree-beargrass (*Nolina bigelovii*) were present on the slopes near the tanks. The lowest fossil record for single-leaf pinyon was at 460 m in the Tinajas Altas Mountains. The lowest elevation record for California juniper was 240 m in a creosotebush desertscrub assemblage in the Butler Mountains.

The midden fossils mostly record woodland plants at low elevations, reflecting dramatic changes in vegetation with Sonoran Desert dominants mostly displaced to refugia, probably in central Sonora. The trough of the Colorado River Valley likely was desertscrub throughout the Pleistocene, with much simpler vegetation changes than at higher elevations. Middens from Picacho Peak, California (just north of Yuma) recorded continuous desertscrub for the last 12,730 years, where Mohave desertscrub with Joshua tree–blackbrush (*Coleogyne ramosissima*)–creosotebush changed to brittlebush (*Encelia farinosa*)–pygmy cedar (*Peucephyllum schottii*)–creosotebush and was later replaced by a simpler Sonoran desertscrub (Cole 1981). The creosotebush–white bursage desertscrub in the flats below the Tinajas Altas Mountains was probably more stable, with less change or impact from the Ice Age climates than the vegetation on rocky slopes above at higher elevations.

Ice Age climates with greater winter rainfall from the Pacific and reduced summer monsoonal rainfall from the tropical oceans likely favored woody cool-season shrubs with northern affinities (Neilson 1986) rather than the summer-rainfall trees, shrubs, and cacti of dry tropical origin and subtropical deserts. Paleoclimatic reconstructions based on the modern distributions of these cool-season species inferred greater winter rainfall, greatly reduced summer monsoon rains, and cooler summers (Van Devender 1990). The Tinajas Altas middens showed a dramatic shift from predominantly winter annuals in Ice Age woodland assemblages to mixed winter-summer annuals as the summer monsoon developed in the Holocene and Sonoran desertscrub formed.

Creosotebush is one of the most important plants in the warm deserts of North America. Unlike most other Sonoran Desert dominants, it evolved in South America and immigrated to the Chihuahuan Desert. The oldest record for creosotebush in North America is a midden sample from the west base of the Tinajas Altas Mountains. A C-14 date of 18,700 ybp on its twigs documents its presence in the area during the last full glacial.

Table 3. Radiocarbon dates from the Tinajas Altas and Butler Mountains, Arizona. AA = tandem linear accelerator dates.

Sample	Age (ybp)	Lab No.	Material Dated
Butler Mts. #6	16,400±820	AA-617	Pinus microphylla
Butler Mts. #3A	11,250±410	AA-769	Larrea divaricata
Butler Mts. #3B	11,060±360	AA-770	Juniperus californica
Butler Mts. #5	10,360±430	AA-537	Larrea divaricata
Butler Mts. #3B	10,170±610	AA-768	Larrea divaricata
Butler Mts. #6	8590±570	AA-538	Larrea divaricata
Butler Mts. #1	8160±160	A-2652	Neotoma sp.
Butler Mts. #6	7530±90	av. AA-538 & A-3389	
Butler Mts. #6	6490±90	A-3389	Neotoma sp.
Butler Mts. #4	3820±70	A-3517	Neotoma sp.
Butler Mts. #2C	740±50	A-3911	Neotoma sp.
Butler Mts. #2B	220±70	A-3910	Neotoma sp.
Butler Mts. #2A	610±50	A-3790	Neotoma sp.
Tinajas Altas #15B	>43,200	AA-1720	Juniperus californica
Tinajas Altas #15B	>37,000	A-3392	Yucca brevifolia
Tinajas Altas #18B	18,700±1050	AA-536	Larrea divaricata
Tinajas Altas #16A	18,530±1070	AA-780	Juniperus californica
Tinajas Altas #18B	16,150±400	A-3407	Juniperus californica
Tinajas Altas #15A	15,680±720	AA-452	Pinus monophylla
Tinajas Altas #18A	15,050±350	A-3459	Juniperus californica
Tinajas Altas #20A	11,040±270	A-3393	Juniperus californica
Tinajas Altas #2B	10,950±90	USGS-958	Neotoma sp.
Tinajas Altas #3B	10,600±420	AA-781	Ambrosia dumosa
Tinajas Altas #3B	10,300±110	USGS-959	Neotoma sp.
Tinajas Altas #12A	10,070±110	A-3730	Neotoma sp.
Tinajas Altas #14	9900±200	A-3570	Juniperus californica
Tinajas Altas #1B	9790±240	A-2494	Neotoma sp.
Tinajas Altas #3A	9700±100	USGS-957	Neotoma sp.
Tinajas Altas #1A	9230±140	A-2122	Juniperus californica
Tinajas Altas #2A	8970±75	USGS-956	Neotoma sp.
Tinajas Altas #16C	8910±80	A-3520	Neotoma sp.
Tinajas Altas #16B	8700±110	A-3647	Neotoma sp.
Tinajas Altas #16C	8660±140	A-3566	Neotoma sp.
Tinajas Altas #16A	8650±430	AA-779	Parkinsonia florida
Tinajas Altas #16A	7860±100	A-3521	Neotoma sp.
Tinajas Altas #16A	8255	av. AA-779 & A-8255	
Tinajas Altas #13B	5940±70	A-3507	Neotoma sp.
Tinajas Altas #13A	5860±60	A-3506	Neotoma sp.
Tinajas Altas #13B	5820±310	AA-777	Bursera microphylla
Tinajas Altas #20C	5080±80	A-3565	Neotoma sp.
Tinajas Altas #2A	4490±230	AA-535	Carnegiea gigantea
Tinajas Altas #20B	4010±70	A-3535	Neotoma sp.
Tinajas Altas #20A	1770±300	AA-778	Prosopis glandulosa/velutina
Tinajas Altas #11	1230±100	A-3738	Jatropha cuneata
Tinajas Altas #20C	245±250	AA-525	Parkinsonia microphylla

the time of maximum development of continental and montane glaciers at high latitudes and elevations in North America, although it surely emigrated from South America much earlier (Hunter et al. 2001; Lia et al. 2001). These Ice Age creosotebushes were growing in a California juniper-Joshua tree woodland. In North America, evolution in creosotebush resulted in the widespread *Larrea divaricata* subsp. *tridentata* with three chromosome races roughly found in the Chihuahuan (diploid), Sonoran (tetraploid), and Mohave (hexaploid) deserts, and the unusual willowy dune creosotebush (var. *arenaria*) in the Algodones Dunes of California and the Gran Desierto of northwestern Sonora (Felger 2000). In South America there are four species of *Larrea*, all diploids. According to Hunter et al. (2001), the full-glacial creosotebush in the Tinajas Altas was the same Sonoran Desert tetraploid chromosomal race that occurs in the area today. Surprisingly, they also reported all three chromosomal races in middens from Picacho Peak, California, to the northeast across the Colorado River from Yuma. All of the late Wisconsin creosotebush midden records were diploids or hexaploids from below 310 m in the Lower Colorado River Valley. The first Mohave Desert hexaploids appeared in the Picacho Peak midden record at 8420 ybp (Hunter et al. 2001). This is interesting because Vasek (1980) inferred that the King Clone creosotebush (Sternberg 1976) in the Mohave Desert of California, with an average diameter of about 14 m, was 11,700 years old, even though creosotebush was not found in packrat middens in the nearby Lucerne Valley before 5880 ybp (King 1976). The King Clone may be younger than popular myth would like.

The packrat midden assemblages are rich with 25 to 60 plant species per sample. The fossil records of the majority of the plants, which are not structural dominants, provide different insights. Holly-leaf bursage (*Ambrosia ilicifolia*), as well as desert agave (*Agave deserti*), desert tree-beargrass, many-headed barrel-cactus (*Echinocactus polycephalus*), mountain barrel-cactus (*Ferocactus cylindraceus*), and Spanish bayonet (*Hesperoyucca whipplei*) were present in Ice Age woodlands in Tinajas Altas, unlike Sonoran Desert saguaros and palo verdes, which retreated to Ice Age relictual areas somewhere in Sonora.

Another interesting pattern is that short-lived plants and animals were not affected as much by Pleistocene climates as larger trees, shrubs, and succulents. The midden assemblages have many records of anomalous associations in Ice Age woodland, including holly-leaf bursage with single-leaf pinyon, California juniper, Joshua tree, Mohave sage, and skunk bush (*Rhus aromatica*) in the Tinajas Altas Mountains (Van Devender 1990). The composition of plant communities has changed continuously because each individual species responds differently to climate events, and climate fluctuations range from thousands of years on continental or global scales to months or days for regional or local droughts or freezes. Even in pristine-appearing habitats, some species are increasing, decreasing, absent, or just arrived in response to some drought, rainfall, freeze, or other climate event (see *Amaranthus crassipes* and *Cyperus squarrosus* in the species accounts).

Middens have provided remarkable insight into evolutionary processes. Over 400 species of plants and small animals have been identified from Sonoran Desert packrat middens. These fossils are indistinguishable from their living descendents, no matter what their age. Midden fossils tell us that species are well adapted to fluctuating climates, and simply expand or shrink their ranges.

Considering that there were 15 to 20 glacial/interglacial cycles in the Pleistocene, species distributions and community compositions have been very dynamic in the last 2.4 million years. Similar successional stages from widespread woodlands to expanded deserts likely occurred during each interglacial. Although the late Holocene desertscrub communities likely resembled the original late Miocene Sonoran Desert, relatively modern desertscrub communities were developed for about 5–10% of the 2.4 million years of the Pleistocene. Ice Age climates with woodlands in the desert lowlands typical of about 12,000 ybp persisted for about 80–90% of this period (Porter 1989; Winograd et al. 1997).

Middens in the Tinajas Altas Mountains yielded at least 119 plant taxa, although not all could be identified to species (Van Devender 1990, and this publication, Table 4). Of these, about 28 taxa no longer occur in the flora, including the community dominants single-leaf pinyon, California juniper, and Joshua tree. Other woodland and Mohave plants no longer found in the area are white sage (*Artemisia ludoviciana*), cliff goldenbush (*Ericameria cuneata*), turpentine bush (*E. laricifolia*), green rabbitbrush (*E. teretifolia*), Spanish bayonet, a mint (*Monardella arizonica*), pancake prickly-pear (*Opuntia chlorotica*), skunk bush, Mohave sage, and even a few winter annuals (*Calycoseris parryi, Cryptantha utahensis, Daucus pusillus, Festuca microstachys*, and *Thysanocarpus curvipes*). Among the fossil specimens, 16 species of trees, shrubs, and succulents are shown in a diagram in Van Devender et al. (1990). The rest are published here for the first time.

The inference from the packrat chronicles is that you look at the modern communities, and most of the larger trees and shrubs you see have immigrated into the Tinajas Altas Mountains during the Holocene (9–11 thousand years ago). Other species such as desert agave and holly-leaf bursage, Lower Colorado Valley regional endemics, and many short-lived plants and small animals, probably have been here for most of the Pleistocene. Unlike saguaros and palo verdes, they did not retreat and then return. This scenario shows that although modern and fossil species are virtually identical, the vegetation and community composition of the region has changed dramatically and continuously through time.

Table 4. Tinajas Altas plants known from the fossil record. Plants no longer present in the flora area are indicated with two dagger symbols (††). Some fossils identifiable only to genus or a species group might represent species not present today or may be the same as ones now present; these are shown with dagger symbols and a question mark (††?).

GYMNOSPERMS

CUPRESSACEAE
Juniperus californica††
EPHEDRACEAE
Ephedra aspera
PINACEAE
Pinus monophylla††

ANGIOSPERMS

AMARANTHACEAE
Amaranthus fimbriatus
Amaranthus sp./spp.††?
Atriplex polycarpa
ANACARDIACEAE
Rhus cf. aromatica††
APIACEAE
Daucus pusillus††
APOCYNACEAE
Asclepias albicans
ASPARAGACEAE
Agave deserti
Hesperoyucca whipplei††
Nolina bigelovii
Yucca brevifolia††
ASTERACEAE
Ambrosia confertiflora††
Ambrosia dumosa
Ambrosia ilicifolia
Ambrosia salsola
Artemisia ludoviciana††
Bebbia juncea
Brickellia atractyloides
Brickellia coulteri††
Calycoseris parryi††
Chaenactis stevioides
Encelia farinosa
Ericameria cuneata††
Ericameria laricifolia††
Ericameria teretifolius††
Geraea canescens
Gymnosperma glutinosum
Heterotheca sp.††
Perityle emoryi
Peucephyllum schottii
Pleurocoronis sp./spp.††?
Porophyllum gracile
Rafinesquia neomexicana
Trixis californica
Xanthisma spinulosus
BORAGINACEAE
Amsinckia intermedia
Amsinckia tessellata
Cryptantha barbigera
Cryptantha maritima
Cryptantha pterocarya
Cryptantha racemosa
Cryptantha utahensis††
Pectocarya heterocarpa
Pectocarya platycarpa
Phacelia sp.††?
BRASSICACEAE
Descurainia pinnata
Draba cf. cuneifolia
Lepidium lasiocarpum
Lepidium sp./spp.††?
Thysanocarpus curvipes††
BURSERACEAE
Bursera microphylla
CACTACEAE
Carnegiea gigantea
Cylindropuntia acanthocarpa
Cylindropuntia bigelovii
Cylindropuntia ramosissima
Echinocactus polycephalus
Echinocereus sp./spp.††?
Ferocactus cylindraceus
Mammillaria cf. grahamii
Mammillaria sp./spp.††?
Opuntia basilaris
Opuntia chlorotica††
CROSSOSOMATACEAE
Crossosoma bigelovii
EUPHORBIACEAE
Ditaxis lanceolata
Ditaxis neomexicana
Ditaxis sp./spp.††?
Euphorbia micromera†† &/or E. polycarpa
Euphorbia sp./spp.††?
Jatropha cuneata
FABACEAE
Acmispon rigidus
Dalea mollis
Lupinus sp.††?
Olneya tesota
Parkinsonia florida
Prosopis glandulosa &/or P. velutina††?
Senegalia greggii
FOUQUIERIACEAE
Fouquieria splendens
GERANIACEAE
Erodium texanum
KOEBERLINIACEAE
Koeberlinia spinosa††
KRAMERIACEAE
Krameria erecta
LAMIACEAE
Hyptis albida
Monardella arizonica††
Salvia mohavensis††
LOASACEAE
Mentzelia puberula
Petalonyx linearis
MALVACEAE
Abutilon sp./spp.††
Hibiscus denudatus
Sphaeralcea sp./spp.††?
NYCTAGINACEAE
Boerhavia wrightii
Mirabilis laevis
OROBANCHACEAE
Castilleja sp./spp.††
PLANTAGINACEAE
Penstemon sp.††?
Plantago ovata
POACEAEAE
Aristida adscensionis
Aristida purpurea
Bouteloua aristidoides
Bouteloua barbata var. barbata &/or var. rothrockii††?
Bouteloua repens††
Dasyochloa pulchella
Festuca microstachys††
Festuca octoflora
Heteropogon contortus
Hilaria rigida
Muhlenbergia microsperma
Setaria macrostachya††
Stipa speciosa
POLYGONACEAE
Chorizanthe brevicornu
Chorizanthe rigida
Eriogonum fasciculatum
Eriogonum inflatum
Eriogonum wrightii
RANUNCULACEAE
Anemone tuberosa††
RHAMNACEAE
Condalia cf. globosa††
Ziziphus obtusifolia
RUBIACEAE
Galium stellatum
RUTACEAE
Thamnosma montana
SANATALACEAE
Phoradendron californicum
SOLANACEAE
Lycium macrodon
Lycium sp./spp.††?
Physalis sp./spp.††?
Solanum cf. hindsianum††
VERBENACEAE
Glandularia sp./spp.††
ZYGOPHYLLACEAE
Larrea divaricata

THE COLLECTORS

Botanists have documented the flora of Tinajas Altas for more than a century. The collectors of specimens cited in this flora are listed here. The main repository of their collections is at ARIZ or as indicated. There are, however, more specimens from other collectors that we do not cite to avoid duplication of information (also see Southwest Environmental Information Network 2011).

Marc A. Baker. 24 January 1999, with Ami Pate (ASU).

R.J. Blackwell. 15 April 1932, with A. B. Akens.

Rodney G. Engard.18 April 1976 (ASU), with Russell A. Haughey.

Richard Felger. 3 and 4 February 1990, with Bill Broyles, Stephen Bell, Gayle Hartmann, Paul Huddy, and Carl Wachtmeister. 16 June 1992, with Bill Broyles. 18 and 19 March 1998, with Luke Taylor Evans. 29 November 2002, with Curtis McCasland. 10 January 2002, with Curtis McCasland. 25 and 26 October 2004, with Curtis McCasland. 18 February 2005, with Karen Louise Reichhardt. 21 February 2005, with James L. Heard and Karen Reichhardt. 30 December 2005, with Bill Broyles and Stephen Oertle. 20 to 22 November 2008, with Benjamin Theodore Wilder. 28 and 29 March 2010, with Bill Broyles, Luke Taylor Evans, Richard Burton Laugharn, and Joan Evelyn Scott.

Howard Scott Gentry. 28 October 1937. The 1937 collections, labeled "Tinajas Alas, Camino del Diablo," are probably from or near the actual Tinajas Altas waterholes. There are collections at ARIZ and RSA by Gentry from 1 October 1939 that are labeled "Telegraph Pass, Tinajas Altas Mountains" and some of the same date merely labeled "Tinajas Altas" that are presumably also from Telegraph Pass (as evidenced by the specimens collected) and therefore not part of our flora. In 1939 the Gila and Tinajas Altas Mountains were often considered to be a single range.

Edward Alphonso Goldman. 20 November 1913 (US).

Leslie Newton Goodding. 22 November 1934. 5 and 6 December 1935 with Edward W. Hardies. 17 November 1936, with Edward H. Morris. 1 December 1938. 7 March 1940, with Arthur L. Hinkley. The numbers on his herbarium labels often represent various accession numbers of the U.S. Soil Conservation Service in Tucson, where he worked. These numbers are not consecutive, but are sufficient to identify the Tinajas Altas specimens.

Stephen Ferris Hale. 28 March 1981, with Frank W. Reichenbacher. 5 March 1983, with Thomas R. Van Devender and Timothy Louis Van Devender. 26 Mar 1983, with Thomas R. Van Devender.

Richard Ray Halse. 31 March 1973.

Charles F. Harbison. 6 and 9 March 1937 (ARIZ, SD). The numbers on his herbarium labels represent accession numbers at SD; he did not use collection numbers for his herbarium specimens.

George J. Harrison. 5 March 1927, with G. O. Belden. 28 and 29 March 1930, with Thomas Henry Kearney.

Wendy Caye Hodgson. 18 April 1983 and 8 March 1984 (DES), with Rodney Engard. 11 Feb 1993, (DES), with Lynda P. Kozak, Liz Ecker, and Ted Anderson.

Thomas Henry Kearney. 29 March 1930, and 23 and 25 March 1935. On many labels it is not apparent if the collection number is that of Kearney, George J. Harrison, or Robert H. Peebles.

Edwin Bernard Kurtz. 17 and 18 April 1948, with William Frank McCaughey and Horace S. Haskell.

Cynthia A. Lindquist. 25 and 26 March 1983. See Thomas R. Van Devender.

Steven Paul McLaughlin. 19 and 20 February 1979, with Janice E. Bowers, Martin Karpiscak, Arthur M. Phillips III, Barbara G. Phillips, E. M. Peterson, and J. M. Downs.

Roger E. McManus. 29 February 1976, with Paul Fugate and Steven P. McLaughlin.

Edgar Alexander Mearns. 14 and 21 February 1894 (CAS/DS, US). The first set of his specimens is at US, with duplicates at numerous other herbaria. See Mearns (1907).

Gale W. Monson. 25 September 1955 (herbarium at Cabeza Prieta National Wildlife Refuge headquarters, Ajo).

J.R. Morrison. 16 April 1993 and 10 November 1993, with P.J. Walter (ASU).

Robert Hibbs Peebles. 1935 and 1940. See George J. Harrison and Thomas Kearney.

Timothy Reeves. 12 February 1977 with Donald J. Pinkava and J.B. Rodriguez (ASU). "My collection numbers are *5352–5452*, so there were 101 collections that day" (Tim Reeves, personal communication, 31 July 2008). Unfortunately not all 101 seem to be at ASU, but at least 81 were accounted for in Southwest Environmental Information Network (2011). A few Reeves collections at ASU are entered as Pinkava collections, but the numbers are Reeves', e.g., *Dudleya arizonica, Pinkava R5370.*

Frank W. Reichenbacher. 9 and 10 March 1980, with Thomas R. Van Devender, Sandra Hunt Stein, etc. (see Thomas Van Devender). Also 28 March 1981.

Forrest Shreve. 26 and 27 March 1932. 21 March 1933. Edward Tattnal "Tad" Nichols IV (2007: 89, Fig. 9.5) shows a photo of himself, Thomas Dwight Mallery, Shreve, and Ira Wiggins at "Tinajas Altas, April 1933" (reproduced in Fig. 16). He provides a fine narrative of the trip and tells us, "The trip was about five or six nights, with two nights at Tinajas Altas" (Nichols 2007: 88). The date, however, must have been in March and not April.

Norman Montgomery Simmons. 21 May 1965. He was assistant refuge manager, Cabeza Prieta National Wildlife Refuge, from 1961 to 1966, during which time he collected plants on the Refuge and adjacent areas (Felger & Broyles 2007; Simmons 1966, 2007).

Peter Christian Sundt, Jr. 2 April 2011, with Mara MacKinnon and Jim Malusa (*Psorothamnus fremontii*; see *Olneya tesota* in the species accounts).

Thomas Roger Van Devender. 9 and 10 March 1980, with Scott Mills, Gary Paul Nabhan, Barry Spicer, Frank W. Reichenbacher, and Sandra Hunt Stein. 5 and 6 March 1983, with Stephen Ferris Hale and Timothy Louis Van Devender. 25–27 March 1983, with Owen K. Davis, Stephen Ferris Hale, Cynthia Lindquist, and Brent E. Martin. 9 March 1986, with Rebecca Kay Van Devender.

Charles T. Vorhies. 16 April 1924, with Walter P. Taylor.

Grady Linder Webster. 17 March 1980. The first set of his collections is at DAV.

Ira Loren Wiggins. 21 March 1933, with Forrest Shreve and others (see entry for Forrest Shreve; Fig. 16).

Benjamin Theodore Wilder. 20 November 2008, with Richard Felger.

Loraine Yeatts. 21 March 1995. In March 1995 she collected in Cabeza Prieta National Wildlife Refuge and the Tinajas Altas region. Her collections are at ARIZ, CAB, CS and KHD and the herbarium at Cabeza Prieta NWR headquarters, Ajo).

THE FLORA

We present a listing of all the vascular plants known to us from the Tinajas Altas region, from the present-day plants as well as fossils recovered from packrat middens. The vegetation and flora are dynamic, changing even now, and have changed dramatically during the past millennia, along with shifting climate and human presences. This is the first publication of a comprehensive temporal flora for any region and spans more than 43,000 years of plants inadvertently collected and curated by humble packrats (*Neotoma* spp.) and more recently by botanists. We document a total of 255 species in 192 genera and 52 families, of which at least 119 species in 96 genera and 36 families are known from the fossil record and among these fossils at least 28 species in 17 genera and 6 families are no longer present (Tables 4 and 5). A summary of the flora and comparison with adjacent and surrounding regions is shown in Table 6.

Felger and Van Devender (2012) provide an abridged checklist of the present-day flora in a comprehensive work on the Tinajas Altas region by Broyles et al. (2012), and an updated listing of the modern flora is included in a regional checklist by Felger et al. (2012). We include some plants from immediately adjacent localities that are expected to occur in the core area.

The most diverse families, present-day and fossil taxa (Table 7), are the Asteraceae (49 species and 2 hybrids); Poaceae (21 species); Boraginaceae (16 species); Cactaceae (14 species); Brassicaceae, Euphorbiaceae, Fabaceae, and Solanaceae (10 species each); Polygonaceae (9 species); and Nyctaginaceae (8 species). This floristic spectrum represents somewhat of a departure from the usual floristic makeup of the present-day Sonoran Desert flora (including that of the Gran Desierto of northwestern Sonora) in which the most diverse families,

Fig. 16. Botanizing at Tinajas Altas, March 1933. From left to right: Dwight Mallery, Ira L. Wiggins, Forrest Shreve, and Tad Nichols. Photo by Tad Nichols.

in decreasing order, are the Asteraceae, Poaceae, Fabaceae, and Euphorbiaceae (e.g., Felger 2000; Van Devender et al. 2010). The most diverse genera in the Tinajas Altas region are *Cryptantha* (7 species, including one fossil), *Ambrosia* (6 species and 1 hybrid), *Eriogonum* (6 species), *Euphorbia* (5 species), and *Boerhavia*, *Cylindropuntia*, and *Lycium* each with 4 species.

There are 12 non-native species in the flora, which is only 5.3% of the total modern flora. Across the Sonoran Desert region this extremely low percentage of non-natives is matched only in the Gran Desierto dune fields of northwestern Sonora (Felger 2000) and some Gulf of California islands (Felger & Wilder 2012; Felger et al. 2011; Van Devender et al. 2009; Wilder & Felger 2010; Wilder et al. 2007). Sahara mustard (*Brassica tournefortii*) and Arabian grass (*Schismus arabicus*) are the only invasive species that are likely impacting native plants (e.g., Felger 2000; Felger et al. 2003; Felger et al. 2012). Red brome (*Bromus madritensis* subsp. *rubens*) and buffelgrass (*Cenchrus ciliaris*) are serious invasives elsewhere in the Sonoran Desert, but have not become a problem in the Tinajas Altas region, although *Cenchrus ciliaris* poses a potential threat. *Boerhavia coccinea* (native to North America but not to southwestern Arizona) and netleaf goosefoot (*Chenopodium murale*) are localized at the Tinajas Altas visitor area, while the two *Sonchus* species are widely scattered but not common. *Lactuca serriola* is highly localized and *Erodium cicutarium* and *Eragrostis cilianensis* are well established but scarcely seem invasive in the flora area. *Mollugo cerviana*, reported to be non-native in the New World, is an innocuous small annual.

Species Accounts

The plants in this flora are grouped as ferns and lycophytes, gymnosperms, dicotyledons (eudicots), and monocotyledons. Within these categories the plants are listed alphabetically by family, genus, and species. Plant families follow the APG III format (Angiosperm Phylogeny Group; e.g., Stevens 2008). Selected, pertinent

TABLE 5. Floral diversity of the Tinajas Altas region.

	Families	Genera	Species
Total modern & fossil records	52	192	255
Modern records	46	175	227
Fossil records	36	96	119

TABLE 6. Present-day floral diversity of the Tinajas Altas and nearby and surrounding areas. Taxa are species, subspecies, varieties, and hybrids. Organ Pipe = Organ Pipe Cactus National Monument, Cabeza Prieta = Cabeza Prieta National Wildlife Refuge, Pinacate Reserve = Reserva de la Biosfera El Pinacate y Gran Desierto de Altar, Dry Borders = the six contiguous protected areas of Organ Pipe, Cabeza Prieta, Sonoran Desert National Monument, Barry M. Goldwater Range, Pinacate Reserve, and the Reserva de la Biosfera Alto Golfo de California y Delta del Río Colorado (Felger & Broyles 2007).

	Tinajas Altas	Organ Pipe	Cabeza Prieta	Pinacate Reserve	Dry Borders
Taxa	227	655	423	479	862
Non-native species	12	72	37	37	91
Genera	175	395	266	–	448
Families	46	93	63	70	107
Acres	80,000	330,689	860,010	1,765,915	7,515,221
Hectares	32,375	133,825	348,034	714,656	3,041,302

TABLE 7. The ten most diverse plant families of the Tinajas Altas region.

Families	Total genera	Total species	Modern records	Fossil records
Asteraceae	35	49+ 2 hybrids	43+ 2 hybrids	24
Poaceae	17	21	18	13
Boraginaceae	7	16	15	8
Cactaceae	9	14	13	10
Fabaceae	8	10	10	7
Brassicaceae	10	10	9	4
Solanaceae	6	10	9	4
Euphorbiaceae	4	10	10	5
Polygonaceae	3	9	9	5
Nyctaginaceae	4	8	8	2

synonyms are in square brackets following the accepted scientific name. Vernacular (common) names follow the scientific names and when known are given in English, Spanish, and O'odham, respectively. The Spanish-language names are italicized. The O'odham names are from Felger et al. (2007b). Plants not native to the flora region are marked with an asterisk (*). Fossil taxa and/or specimens are indicated with a dagger symbol (†). Ethnobotanical uses are from Felger (2007). Years before present (ybp) are the approximate years before 1950, based on radiocarbon dating—therefore some summarized dates in the species accounts are about one half century older than the ybp-radiocarbon date. Flower color refers to the dominant color and not necessarily to a specific flower part or structure. It may be assumed that the species are common unless otherwise stated. The brief descriptions and identification keys for the various taxa are based on plants from the flora area and are not necessarily applicable to other regions. More extensive descriptions can be found in works by Felger (2000), Felger et al. (2007b), Wiggins (1964), the Vascular Plants of Arizona Project (Vascular Plants of Arizona Editorial Committee 1992), and the Jepson Flora Project (2012). Nomenclature follows the regional checklist by Felger et al. (2012).

This floristic account is a specimen-based except for some records verified by an observation, photo documentation, or published report. Extensive collections from the Tinajas Altas region are at ARIZ, ASU, and DES.

There are often multiple collections of a given species or taxon and in such cases we cite only a few specimens for each species or taxon. Extensive references to herbarium specimens can be found at Southwest Environmental Information Network (2011; also known as SEINet) and other herbarium databases.

Specimens cited are at the University of Arizona Herbarium (ARIZ), unless otherwise indicated by the standardized abbreviations for herbaria (Index Herbariorum 2009), or the herbarium at Cabeza Prieta National Wildlife Refuge headquarters in Ajo, Arizona, identified as CAB. All herbarium specimens cited have been seen by Felger, although some have been seen as images, unless otherwise noted. The name of the collector and collection number is given. In cases where more than one collector is listed on a label, generally only the first collector's name is stated. Locality descriptions and other information on herbarium labels generally are abridged. If no collection number is provided on the herbarium label, then the specimen is identified by the date of collection, for example, *Harbison 6 Mar 1937.* When the date of collection is significant, such as collections of historic interest, especially non-native species, both the collection number and date are given. It should be noted that the labels on many of the early herbarium specimens merely state "Tinajas Altas Mountains" or "Tinajas Altas." Before the mid-twentieth century it was customary to regard the Gila and Tinajas Altas Mountains as a single range and thus some of these specimens might be from the Gila Mountains, which currently are regarded as the range to the north of the Tinajas Altas.

Although we provide extensive documentation of plants from this region, intrepid botanists should be able to discover additional species.

KEY TO THE MAJOR PRESENT-DAY PLANT GROUPS AND FAMILIES

1. Plants spore bearing, without flowers or seeds; leaves like those of typical ferns or scale-like and less than 40 cm long **FERNS AND LYCOPHYTES**
1. Plants seed bearing; leaves various or none.
    2. Shrubs with paired (opposite) scale leaves and small cones, the male and female cones on separate plants, the females cones 1-seeded; not producing flowers **GYMNOSPERM, Ephedraceae** (page 189)
    2. Plants with flowers and seeds; leaves various or none **ANGIOSPERMS—FLOWERING PLANTS**
        3. Agaves, cattails, grasses, sedges, bulb-producing plants, or large non-succulent rosette plants **MONOCOTYLEDONS** (page 244)
        3. All other plants, not as above **DICOTYLEDONS (eudicots)** (page 190)

FERNS AND LYCOPHYTES

1. Leaves more than 10 mm long, deeply divided (pinnatifid) or compound, not scale-like, the petioles conspicuous **Pteridaceae**
1. Leaves less than 4 mm, simple, somewhat scale-like and sessile **Selaginellaceae**

PTERIDACEAE—MAIDENHAIR FERN FAMILY

1. Leaves once pinnate, the blades more than 5 times as long as wide, the petioles about ⅛ as long as the blade **Astrolepis**
1. Leaves 2–3 times pinnate or deeply pinnatifid, the blades less than twice as long as wide, the petioles usually at least half as long as the blade.
    2. Leaflets densely woolly, the hairs obscuring the surfaces and extending beyond the margins **Cheilanthes**
    2. Leaflets not densely woolly, the upper surfaces green and not obscured by hairs, the hairs not extending beyond the margins **Notholaena**

Astrolepis cochisensis (Goodd.) D.M. Benham & Windham subsp. **cochisensis** [*Notholaena cochisensis* Goodding] SCALY CLOAK-FERN, JIMMY FERN

Small, tufted ferns with slender, pinnate leaves. Among rocks at higher elevations.

Above Tinajas Altas, 1500 ft, *Van Devender 10 Mar 1980.*

Cheilanthes parryi (D.C. Eaton) Domin [*Notholaena parryi* D.C. Eaton] PARRY'S LIP-FERN

Small desert ferns with short rhizomes and gray-hairy leaves.

Sheltered among rocks throughout the mountains. This fern extends into drier habitats than any other Sonoran Desert fern.

Tinajas Altas, *Wiggins 21 Mar 1933.* Tinajas Altas, above the tinaja containing *Typha*, shady crevices, in vertical granite faults, 18 Apr 1976, *Engard 920* (ASU). Frontera Canyon, 18 Mar 1998, *Felger* (observation).

Notholaena californica D.C. Eaton subsp. **californica** [*Cheilanthes deserti* Mickel] CALIFORNIA CLOAK-FERN

Small tufted desert ferns with bead-like leaf divisions.

Sheltered among rocks in the mountains to the summit.

Tinajas Altas, 6 Mar 1937, *Harbison 16826* (SD). Tinajas Altas Pass, lower slopes, 1200 ft, *Reeves 5353* (ASU). Surveyors Canyon, canyon bottom just below Surveyors Tank, *Felger 10-204*. Frontera Canyon, 18 Mar 1998, *Felger* (observation).

SELAGINELLACEAE—SPIKE-MOSS FAMILY

Selaginella eremophila Maxon. DESERT SPIKE-MOSS

Mat-like plants with scale leaves; the plants curl up when dry, and quickly expand with rain to reveal green foliage.

Rocky slopes, mostly north- and northeast-facing exposures and especially at higher elevations. Spike-moss is surprisingly scarce in the vicinity of the Tinajas Altas waterholes, which is likely a result of grazing by desert bighorn. Tim Reeves, an expert on desert ferns, made the following entry in his field notebook for 12 February 1977, at Tinajas Altas: "All ferns [the three species] green and healthy. Suggests fairly recent rain. Area searched for *Selaginella eremophila*, none seen, various good habitat [for it]."

SE side of Tinajas Altas Mts, ca. 2 mi SE of Tinajas Altas, dense, locally extensive mats, not seen elsewhere, *Felger 92-619*. 0.8 mi SE of Tinajas Altas camping area, steep N-facing slope, a patch, 10 × 10 m, *Reichenbacher & Hale 28 Mar 1981*. Tinajas Altas Canyon, among rocks, ca. 0.7 km SW of upper tinaja, 1800 ft, shaded niche at canyon bottom, localized (not seen elsewhere in vicinity), *Felger 98-134*.

GYMNOSPERMS–CONE-BEARING PLANTS

CUPRESSACEAE—REDWOOD OR CYPRESS FAMILY

†Juniperus californica Carrière. CALIFORNIA JUNIPER

Shrubs or small trees. This was the common low-elevation juniper in southwestern Arizona during the late Wisconsin age. It grew in the flora area from about 9000 to more than 43,000 years ago. The early Holocene and late Wisconsin age records from the Butler Mountains at 240 m are the lowest elevation records for any juniper in the Sonoran Desert region. The nearest present-day population occurs at higher elevations in northwestern Arizona where it is disjunct from the primarily distribution along the Pacific side of California and mountains in northern Baja California.

†Butler Mts, twigs, seeds, 10,360–11,250 ybp (3 samples). †Tinajas Altas, twigs, seeds, 8970–18,700 ybp (14 samples), & >43,000 ybp.

EPHEDRACEAE—JOINT-FIR FAMILY

Ephedra aspera Engelm. ex S. Watson [*E. nevadensis* S. Watson var. *aspera* (Engelm. ex S. Watson) L.D. Benson] BOUNDARY EPHEDRA; *CAUTILLO*; KU'UKPALK

Woody shrubs; twigs green with paired, short, brown scale-leaves.

Mostly on rocky slopes. Two-leaved ephedras have been prevalent in the region since at least 43,000 years ago. The fossils were originally identified as *E. nevadensis*, but are more likely to be *E. aspera*. We are unable to distinguish one from the other on the basis of fossil specimens, and they are indeed closely related and often impossible to distinguish. It was an important medicinal plant (Felger 2007).

Ca. ⅓ mi S of Tinajas Altas, *Hodgson 2100* (DES). Tinajas Altas Canyon, *Felger 08-176*. Borrego Canyon, 16 Jun 1992, *Felger* (observation). †Butler Mts, twigs, bracts, seeds, 740–11,250 ybp (7 samples). †Tinajas Altas, twigs, seeds, 1230–18,700 (19 samples), & >43,000 ybp.

PINACEAE—PINE FAMILY

†Pinus monophylla Torr. & Frém. SINGLE-LEAF PINYON; *PIÑÓN*

Small trees. Unlike most pinyon taxa, the fascicles bear only a single leaf. Cones relatively small with wingless, edible seeds.

Pinyons were widespread in the lowland late Wisconsin Ice Age woodlands in sub-Mogollon Arizona. Tinajas Altas is the lowest-elevation regional record for a pine in the Pleistocene. This pinyon presently occurs in northwestern Arizona, mountains in Baja California, California, Idaho, Nevada, New Mexico, and Utah.

The fossils have slender needles, indicating relationship with *P. edulis* Engelm. var. *fallax* Little, which today occurs in woodland and chaparral below the Mogollon Rim in central Arizona and in southern New Mexico. "*Pinus edulis* var. *fallax*…appears to combine features of *P. edulis* and *P. monophylla*. More study is needed" (Kral 1993: 383).

†Tinajas Altas, 460 m, 11,040–15,680 ybp, & >43,000 ybp.

ANGIOSPERMS—FLOWERING PLANTS

DICOTYLEDONS (EUDICOTS)

1. Parasitic plants; without chlorophyll, or if they have chlorophyll (green) then the parasitic attachment is well above the ground (stem parasites).

  2. Broomrape; root parasites, attached to host roots underground ____ **Orobanchaceae**

  2. Mistletoe; stem parasites, attached to shrub or tree branches ____ **Santalaceae**

1. Plants with chlorophyll and not obviously parasitic.

  3. Composites; individual flowers (florets) generally small and borne in a head resembling a single large flower, the head surrounded by a series of somewhat sepal-like bracts (phyllaries) forming an involucre, the heads often sunflower- or daisy-like, with a central group of tubular disk florets often surrounded by a ring of ray florets, or the heads with disk florets only, or all florets ray-like with a strap-shaped corolla; ovary of individual florets inferior, the fruit a cypsela (achene), topped by scales or bristles forming the pappus, or the pappus sometimes none ____ **Asteraceae**

  3. Inflorescence and flowers various but not grouped into heads subtended by a series of bracts forming an involucre, and often with green sepals instead of a pappus.

    4. Plants leafless or essentially so, or with scale leaves or few soon deciduous and reduced leaves (includes trees, shrubs, and some succulents such as cacti but not annuals and generally not plants that are seasonally leafy) ____ **Key 1**

    4. Plants leafy, at least seasonally, or the young growth leafy (when plants are dormant, check for leaf scars or dried leaves).

      5. Vines, the stems twining on other plants or sprawling across the ground ____ **Key 2**

      5. Plants not vining.

        6. Trees and shrubs, conspicuously woody.

          7. Leaves compound ____ **Key 3**

          7. Leaves simple.

            8. Leaves opposite (and sometimes whorled) ____ **Key 4**

            8. Leaves alternate ____ **Key 5**

        6. Herbaceous and non-woody plants, or only moderately woody at base; annuals and perennials.

          9. Plants with conspicuously succulent leaves and/or stems (borderline cases key out in both couplets) ____ **Key 6**

          9. Plants not conspicuously succulent.

            10. Leaves compound ____ **Key 7**

            10. Leaves simple.

              11. Larger leaves basal or in a conspicuous basal rosette (basal rosette leaves may be deciduous), the flowering stems leafless or stems with leaves substantially reduced in size and number (borderline cases key out in both leads) ____ **Key 8**

              11. Midstem leaves well developed; if a basal rosette present, then the stem leaves conspicuous and usually at least ¼ to ⅓ as large as the basal leaves.

                12. Midstem leaves opposite (a few nodes may bear alternate leaves) or whorled ____ **Key 9**

                12. Midstem leaves alternate ____ **Key 10**

KEY 1

Plants Leafless or Essentially So, or with Scale Leaves

(note: excluded are most seasonally leafless plants and annuals that have shed their leaves)

1 Stems succulent.

  2 Cactus; sap not milky; with spine-bearing areoles; leaves none or alternate and reduced, succulent, and soon deciduous ____ **Cactaceae**

  2. Sap milky; plants unarmed (spineless), the stems reed-like; leaves opposite, not succulent, and soon deciduous ____ **Apocynaceae** (*Asclepias*, in part)

1. Stems not succulent.

  3. Stem nodes with semi-persistent and opposite scale leaves ____ **Gymnosperms: Ephedraceae**

  3. Leaves few, quickly deciduous, usually not scale-like (plants seasonally leafless or nearly so and thus placed in this key).

    4 Stems yellow-green, conspicuously dotted with lens-shaped glands, the plants noticeably aromatic (citrus-like); leaves sparse and quickly deciduous, the upper leaves reduced and scale-like; flowers 1 cm long, tubular and dark bluish purple ____ **Rutaceae**

    4. Stems not dotted with lens-shaped glands, and not noticeably aromatic; flowers not tubular and dark bluish purple.

      5 Composites (leaves present but these can be leafless or nearly so in dry seasons); flowers sessile in heads surrounded by multiple sepal-like bracts (the involucre), the individual fruits 1-seeded ____ **Asteraceae** (*Baccharis sarothroides, Bebbia, Porophyllum, Stephanomeria*)

      5. Each flower on a separate pedicel, flowers not in heads surrounded by bracts, the fruits usually multiple-seeded (not small achenes).

        6 Palo verdes, the stems remaining green for multiple years; large shrubs or trees; flowers yellow or yellow and white, and bilaterally symmetric; fruits more than 2 cm long ____ **Fabaceae** (*Parkinsonia* when leafless)

6. Stems not remaining green for multiple years; shrubs; flowers orange, red, or purple, or if yellow then radially symmetric; fruits less than 2 cm long.

7 Plants unarmed, or if twigs sharp-pointed then less than 1 m tall.

8 Stems brittle, pale bluish-green; flowers red-orange; fruits club-shaped and not spiny **Acanthaceae**

8. Stems tough, not brittle; flowers purple-magenta; fruits bur-like and spiny **Krameriaceae**

7. Plants usually more than 1 m tall and armed with spines or thorn-tipped twigs.

9 Ocotillo; shrubs with wand-like stems mostly unbranched from a common base; nodes regularly spaced and bearing a single stout spine or some stems without spines (leaves quickly drought deciduous); flowers red-orange and tubular; fruits dry at maturity (capsules) **Fouquieriaceae**

9. Much-branched shrubs often with rigid thorn-tipped twigs; flowers small and yellow-green, not tubular; fruits fleshy **Rhamnaceae**

KEY 2

Vines and Plants with Trailing Stems (stems climbing, twining, or trailing like vines; generally does not include plants that merely have prostrate stems)

1. Plants with tendrils; flowers unisexual, yellow or white **Cucurbitaceae**

1. Plants without tendrils; flowers bisexual, white and purplish or lavender, or purplish.

2. Leaves pinnately compound with 3 or more leaflet pairs **Zygophyllaceae** (*Kallstroemia*)

2. Leaves simple.

3. Sap milky; flowers white and pale lavender; fruits 3 cm or more long **Apocynaceae** (*Funastrum*)

3. Sap not milky; flowers bright pinkish purple; fruits less than 1 cm long **Nyctaginaceae** (*Allionia*)

KEY 3

Trees and Shrubs with Compound Leaves

1. Leaves opposite; herbage resinous; leaves deeply notched (actually 2 fused leaflets with entire margins that appear to form a simple leaf); fruits of 5-lobed capsules, breaking into 1-seeded segments; widespread **Zygophyllaceae** (*Larrea*)

1. Leaves alternate, not resinous, with several or more leaflets.

2. Plants unarmed, the herbage strongly aromatic; trunks and limbs often thick, the wood pithy, soft, and semi-succulent; stipules none; leafstalks (petiole and rachis) without glands; fruits globose or nearly so, 1-seeded **Burseraceae**

2. Plants armed or unarmed, not aromatic; trunks and limbs not unusually thick or semi-succulent; stipules generally present (except *Parkinsonia microphylla*); leafstalks sometimes with a prominent gland; fruits of pods, multiple-seeded (*Olneya* pods sometimes 1-seeded) **Fabaceae** (*Olneya, Parkinsonia, Prosopis, Psorothamnus, Senegalia*)

KEY 4

Trees and Shrubs with Simple Opposite Leaves (sometimes with some alternate leaves, or whorled)

1. Leaf margins not entire: serrated, toothed, undulate (wavy), or the leaf tip notched.

2. Creosotebush; herbage resinous/glutinous, glabrous or with small simple hairs; leaves deeply notched (actually 2 fused leaflets with entire margins that appear to form a simple leaf); flowers yellow **Zygophyllaceae** (*Larrea*)

2. Herbage not resinous; plants with branched (dendritic or tree-like) hairs; leaf tips acute to obtuse or rounded, not notched, the leaf margins wavy to toothed; flowers violet **Lamiaceae** (*Hyptis*)

1. Leaves entire.

3. Herbage pubescent; leaves 2 or more cm long; flowers red-orange; fruits of capsules not enclosed in a bag-like calyx **Acanthaceae**

3. Plants glabrous; leaves 1–1.8 cm long; flowers blue and white; fruits enclosed by calyx inflated and hollow like a bag **Lamiaceae** (*Scutellaria*)

KEY 5

Trees and Shrubs with Simple Alternate Leaves

1. Leaves entire

2. Plants armed with spines or thorns.

3. Ocotillo; stems long, wand-like, and spiny, the spines regularly spaced and similar in size, or some stems without spines; flowers tubular, red-orange in terminal inflorescences **Fouquieriaceae**

3. Stems not wand-like, not spiny but the twigs sometimes spinescent at tip; flowers yellowish or purplish, the inflorescences not terminal.

4. Leaf veins conspicuous, usually 3 major veins from the leaf base; flowers radial, small and yellowish; fruits fleshy and smooth **Rhamnaceae**

4. Leaf veins not conspicuous; flowers bilateral, showy and purplish; fruits of bristly burs **Krameriaceae**

2. Plants unarmed.

5. Plants, or at least the leaves, glabrous or glabrate.

6. Stems relatively thick and very flexible, often with knobby short shoots; sap copious, watery or blood-like; flowers unisexual **Euphorbiaceae** (*Jatropha*)

6. Stems not unusually thick and not especially flexible; sap not watery, and blood-like; flowers bisexual **Crossomataceae**

5. Plants with hairs or scales.

7. Flowers unisexual; leaves scurfy whitish gray with sac-like hairs; female flowers enclosed in bracts with small finger-like blunt teeth **Amaranthaceae** (*Atriplex*)

7. Flowers bisexual; hairs simple, not sac-like; flowers not enclosed in bracts.

8. Flowers purple, bilateral, not surrounded by bracts, ca. 15 mm wide; fruits of bristly burs **Krameriaceae**

8. Flowers several in dense clusters surrounded by bracts, white to pink, the individual flowers radial, 5 mm or less wide; fruits of inconspicuous nutlets, not bristly **Polygonaceae** (*Eriogonum* in part)

1. Leaves toothed, lobed, or divided.

9. Plants armed with thorn-tipped twigs; widespread but seldom common in the flora area **Rhamnaceae**

9. Plants unarmed.

10. Plants with star-shaped (stellate) hairs; stamens many, the filaments united into a column **Malvaceae**

10. Plants glabrous or glabrate, or with simple hairs; stamens 1 or 5, not united into a column.

11. Leaf blades firm; flowers bisexual; fruits asymmetric drupes, densely glandular **Anacardiaceae**

11. Leaf blades not firm; flowers unisexual, the male and female flowers very different from each other; fruits not asymmetric, not drupes, and not glandular **Euphorbiaceae** (*Jatropha*)

KEY 6

Non-woody Succulents (stems and/or leaves succulent)

1. Annuals; leaves succulent; flowers bright yellow or red-pink, collapsing with daytime heat; fruits of capsules opening around the middle (circumscissile), with several to many seeds **Portulacaceae**

1. Perennials; leaves not succulent; flowers of various colors, but not bright yellow, open all day; fruits not opening around the middle.

2. Stems semi-succulent, slender, erect, reed- or rush-like, and with milky sap; leaves opposite and very slender (thread-like), few and quickly deciduous; flowers bisexual **Apocynaceae** (*Asclepias* in part)

2. Shrubs with thick stems, not reed-like, the sap not milky; leaves alternate, not thread-like; flowers unisexual **Euphorbiaceae** (*Jatropha*)

KEY 7

Herbaceous Plants with Compound Leaves

(includes plants with highly divided leaves that may appear compound)

1. Leaves opposite (sometimes alternate on first or lower nodes); flowers radial **Zygophyllaceae** (*Fagonia, Kallstroemia*)

1. Leaves alternate or in a basal rosette, not obviously opposite; flowers radial or not.

2. Leaflets (5) 7–9 per leaf, palmately (digitately) arranged; flowers lavender-pink with a yellow spot on the banner petal **Fabaceae** (*Lupinus*).

2. Leaflets pinnately arranged.

3. Sepals and petals each 4; stamens 6; leaves deeply parted or divided **Brassicaceae** (*Descurainia, Lyrocarpa*)

3. Sepals or calyx lobes and petals or corolla lobes each 5; stamens 5 or 10.

4. Stipules none; flowers radial, the corollas sympetalous; stamens 5; styles 2 or 2-branched; fruits of globose capsules **Boraginaceae** (*Eucrypta, Phacelia*)

4. Stipules usually present; flowers bilateral, some or all petals separate; stamens 10; styles 1, the stigma unbranched; fruits of pods, not globose **Fabaceae** (*Acmipon, Dalea, Lupinus*)

KEY 8

Herbaceous Plants with Simple, Basal Leaves (larger leaves in basal rosettes, the stem leaves smaller, reduced or absent. Many of these plants can also be identified in other keys)

1. Perennials from a hardened, somewhat woody base; perianth parts 6, in 2 separate and similar whorls, surrounded by bracts; fruits 1-seeded **Polygonaceae** (*Eriogonum inflatum*)

1. Annuals, cool-season (except *Mollugo*).

2. Plants glabrous, mat-like or prostrate; leaves opposite but crowded, the stipules and sepals white and papery **Caryophyllaceae** (*Achyronychia*)

2. Plants glabrous or hairy; sepals and stipules (if present) not white and papery.

3. Flowers with perianth parts each 4 (sepals or calyx lobes, and petals or corolla lobes).

4. Perianth brown and papery when dry; fruits of globose capsules opening around the middle **Plantaginaceae** (*Plantago*)

4. Perianth not brown and papery; fruits longer than wide, not opening around the middle.

5. Leaves broadly obovate to 4 cm long, with forked and stellate hair; petals white, less than 5 mm long and soon deciduous; stamens 6; ovary superior **Brassicaceae** (*Draba*)

5. Leaves various but not obovate, often more than 4 cm long, glabrate or with simple hairs; petals 5 or more mm long; stamens 8; ovary inferior **Onagraceae**

3. Flowers 5-merous (sepals, petals, and stamens 5) or the petals and stamens many.

6. Plants with rough, branched hairs adhering like Velcro; flower parts mostly more than 5 **Loasaceae** (*Mentzelia*)

6. Plants glabrate, glabrous, or the hairs not sticking like Velcro; flowers 5-merous.

7. Plants small and glabrous or sparsely pubescent.

8. Cool-season annuals, glabrous or with few soft hairs at base; flowering stems zigzag; flowers with red-tipped white petals **Campanulaceae**

8. Warm-weather annuals, glabrous; flowering stems not zigzag; petals none **Molluginaceae**

7. Plants conspicuously hairy.

9. Plants with stiff, calcified or silicified hairs, soft hairs, or glandular hairs; flowers blue, lavender, or pink, or if white then less 10 mm long, open in daytime; fruits separating into 4 or fewer 1-seeded nutlets or capsules with few to many seeds **Boraginaceae** (*Cryptantha, Eucrypta, Nama, Phacelia*)

9. Plants sticky with glandular hairs; flowers white, opening at night and closing in daytime or remaining open in cool weather, corollas 12–20 mm long; fruits of capsules with numerous minute seeds **Solanaceae** (*Nicotiana clevelandii*)

KEY 9

Herbaceous Plants, the Midstem Leaves Simple and Opposite or Whorled

(some nodes may have alternate leaves)

1. Sap milky; flowers unisexual, inconspicuous (often with petal-like white or pink appendages); fruits 3-lobed and 3-seeded **Euphorbiaceae** (*Euphorbia subgenus Chamaesyce*)

1. Sap not milky; flowers bisexual, inconspicuous or not; fruits not 3-lobed, 1-seeded, or the seeds more than 3.

2. Leaves whorled or appearing whorled or densely clustered; flowers small, green and/or white.

3. Warm-weather annuals, usually 3–14 cm tall; stems thread-like; leaves 3.5–11 mm long; ovary and capsule not open at apex **Molluginaceae**

3. Non-seasonal annuals 5–40 cm tall; stems slender but not thread-like; leaves 15–40+ mm long; ovary and capsule open and gaping at apex **Resedaceae**

2. Leaves opposite (sometimes also with some alternate or basal-rosette leaves); flowers of various sizes, not green and/or all white (except *Mirabilis*, Nyctaginaceae).

4. Plants with branched, tree-like (dendritic) non-glandular hairs, moderately to most often densely white woolly; flowers yellow and minute **Amaranthaceae** (*Tidestromia*)

4. Herbage glandular pubescent and usually sticky, hairs not branched.

5. Leaves opposite proximally (below), alternate distally (above), often 6–15 cm long; flowers bilateral, 3–4 cm long; fruits of woody capsules 4–6 cm long with 2 claws 9–14 cm long **Martyniaceae**

5. Leaves mostly not more than 6 cm long; flowers not more than 2 cm long, radial and white, pink, lavender-pink, or bilateral, purple, and in clusters of 3 resembling a single flower; fruits to 1 cm long, indehiscent, 1-seeded, not woody and not clawed **Nyctaginaceae**

KEY 10

Herbaceous Plants, the Midstem Leaves Simple and Alternate

1. Flowers unisexual, small and relatively inconspicuous.

2. Sap milky; fruits 3-lobed (sometimes 1 or 2 lobes or carpels not forming due to abortion), each lobe with a single seed; stigma 3-branched (note: flowers in a flower-like cyathium or cluster) **Euphorbiaceae** (*Euphorbia eriantha*)

2. Sap not milky; fruits 1-seeded, not 3-lobed; petals none.

3. Stems not noticeably weak and not semi-succulent; flowers all unisexual; sepal 5 **Amaranthaceae**

3. Delicate annuals, the stems weak and semi-succulent, the leaves thin and soft; flowers in small clusters with both unisexual and bisexual flowers; sepals 4 **Urticaceae**

1. Flowers bisexual, of various sizes.

4. Plants glabrous; leaves linear-filiform; flowers sessile; petals minute and white; stamens 3; ovary and fruit gaping open at apex **Resedaceae**

4. Plants glabrous or pubescent; leaves not linear-filiform; flowers sessile or not; stamens various but not 3; ovary and fruit not gaping open at apex.

5. Plants with star-shaped (stellate) or tree-like (dendritic) branched hairs.

6. Hairs harsh, dendtritic, and minutely hooked, the leaves and capsules adhering like Velcro **Loasaceae** (*Mentzelia*)

6. Hairs branched but not harsh and not hooked, not sticking like Velcro.

7. Sepals and petals each 4 and separate; stamens 6; fruits laterally compressed, longer than wide **Brassicaceae** (*Descurainia, Lyrocarpa*)

7. Sepals or calyx lobes and petals or corolla lobes each 5; stamens 5 or more, but not 6; fruits rounded or radially symmetrical.

8. Plants often white woolly (less so in shade and when well watered); hairs branched above the base (dendritic); leaves opposite and alternate on the same plant; flowers small and yellow, each enclosed in a cup-shaped involucre becoming hard as the fruit matures, the fruit indehiscent, inconspicuous, and 1-seeded **Amaranthaceae** (*Tidestromia*)

8. Hairs branched from the base (stellate); leaves alternate; flowers of various colors as well as yellow, not enclosed in a cup-shaped involucre; filaments united below into a column; fruits dehiscent capsules or schizocarps **Malvaceae**

5. Plants glabrous or with simple (unbranched) hairs.
    9. Stems yellow-green, dotted with lens-like glands, the plants aromatic, often citrus-like; flowers to 1 cm long, tubular and dark bluish-purple **Rutaceae**
    9. Stems not yellow and green and dotted with lens-like glands, not aromatic or if aromatic then not citrus-like; flowers not tubular and dark bluish-purple.
        10. Flowers with a calyx but without a corolla; fruits indehiscent and 1-seed.
            11. Flowers white, pink or purplish **Nyctaginaceae** (*Allionia, Boerhavia, Mirabilis*)
            11. Flowers inconspicuous, green, drying brown **Urticaceae**
        10. Flowers with a calyx and corolla; fruits of multiple-seeded capsules.
            12. Flowers 4-merous, the ovary inferior: calyx and corolla segments each 4 and attached to the top of the ovary; flowers not purple; stamens 8 **Onagraceae**
            12. Flowers 5-merous, the ovary superior; stamens various but not 8.
                13. Herbage mucilaginous; flowers ca. 4 cm long and bilaterally symmetric; capsules woody, the body more than 4 cm long, with 2 long, hooked, claws **Martyniaceae**
                13. Herbage not mucilaginous; flowers less than 4 cm long or radially symmetric if more than 4 cm long; capsules less than 4 cm long, not woody and not clawed.
                    14. Capsules with 1–4 seeds **Boraginaceae** (*Phacelia, Tiquilia*)
                    14. Capsules with more than 4 seeds.
                        15. Annuals; leaves pinnately lobed or dissected **Boraginaceae** (*Eucrypta, Phacelia*)
                        15. Annuals or perennials; leaf margins entire or shallowly lobed or wavy.
                            16. Annuals; flowers purplish, bilaterally symmetrical **Plantaginaceae** (*Pseudorontium*)
                            16. Annuals or perennials; flowers white or yellowish, radially symmetrical **Solanaceae** (*Datura, Nicotiana obtusifolia, Physalis*)

ACANTHACEAE—ACANTHUS FAMILY

Justicia californica (Benth.) D.N. Gibson [*Beloperone californica* Benth.] Desert hummingbird-bush; *chuparrosa*. **Fig. 15.**

Shrubs with sparse foliage and tubular, red-orange flowers; massive flowering in spring after favorable rains.

Widespread, mostly along washes and canyons and sometimes on rocky slopes; not seen above 1570 ft. *Chuparrosa* attracts hoards of hummingbirds and it is a favorite food plant of bighorn sheep (Russo 1956).

Tinajas Altas, *Shreve 5940*. Canyon above Tinajas Altas, 26 Oct 2004, *Felger* (observation). Tinajas Altas Pass, *Reeves R-5417* (ASU).

AMARANTHACEAE—AMARANTH FAMILY (INCLUDES CHENOPODIACEAE)

1. Leaves opposite or alternate, with branched hairs, usually densely white woolly; flowers bisexual **Tidestromia**
1. Leaves alternate or sometimes opposite below, glabrous or with short simple hairs or glands, or inflated hairs collapsing on leaf surfaces; flowers unisexual or bisexual.
    2. Female flowers and fruits enclosed in sepal-like bracts enlarging as the fruit develops **Atriplex**
    2. Female flowers and fruits not enclosed in sepal-like bracts.
        3. Flowers unisexual; seeds without a distinct rim, shiny or dull **Amaranthus**
        3. Flowers bisexual; seed margins acute with a distinct "rim," the seed surface dull even after removal of pericarp......**Chenopodium**

AMARANTHUS

The two species in the flora area have male and female flowers on the same plant. In *A. palmeri*, which occurs in nearby area, the male and female flowers are on separate plants.

1. Stems ascending, sprawling, or prostrate; inflorescence branches and pedicels sinuous, becoming thickened and corky; fruits indehiscent, scaly and warty **A. crassipes**
1. Stems usually erect or ascending; inflorescence branches and pedicels mostly straight, not thickened and corky; fruits dehiscent (circumscissile) and smooth-surfaced **A. fimbriatus**

Amaranthus crassipes Schldl. var. **crassipes.** Spreading amaranth

Summer annuals, glabrous. Leaf blades and petioles about equal in length; blades obovate to broadly elliptic or nearly orbicular. The inflorescence branches, or peduncles, are markedly thickened and corky, forming a unique, compact, hard knotty structure at the base of the plant and smaller clusters in the leaf axils. Sepals inconspicuous, not fringed. Fruits indehiscent.

This unique amaranth was found localized at several sites along Coyote Wash in October 2004 following exceptional rains.

Coyote Water, *Felger 04-24.*

Amaranthus fimbriatus (Torr.) Benth. FRINGED AMARANTH; *BLEDO, QUELITILLO*; CUHUKKIA I:VAKI

Summer annuals, glabrous. Leaves sessile or short petioled, the blade narrowly lanceolate. Inflorescences "soft," the bracts not spiny or stiff; female sepals conspicuously fringed; flowers small, green and white. Fruits dehiscent. The seeds are edible.

Common and widespread at low elevations, especially washes, bajadas, and canyon bottoms.

Coyote Water, *Felger 04-25.* Tinajas Altas, 26 Oct 2003, *Felger* (observation). †Butler Mts, calyx, 8160 ybp.

†**Amaranthus** sp./spp.

Unidentified amaranths, likely *A. fimbriatus* and/or *A. palmeri*, are recorded at Tinajas Altas dating to about 10 millennia ago (see Doubtful, enigmatic and potential records).

†Tinajas Altas, seeds, 9900 & 10,600 ybp.

Atriplex polycarpa (Torr.) S. Watson. DESERT SALTBUSH; *CHAMIZO CENIZO*; 'ONK 'I:VAKĪ

Woody shrubs. Fruiting bracts bearing 7 to many small, finger-like blunt teeth. Flowering in various seasons, especially with hot weather following rains.

One of the more common and widespread shrubs in the region. Washes, sandy valley plains, bajadas, pediments, and lower slopes. It has been in the region for more than 10,400 years ago.

Camino del Diablo, E of Raven Butte, *Felger 02-04.* SW side of Tinajas Altas Mts, flats and granitic hills, 10 Jan 2002, *Felger* (observation). †Butler Mts, leaves, 10,360 ybp.

***Chenopodium murale** L. NETLEAF GOOSEFOOT; *CHUAL, CHOAL*; 'ONK 'I:VAKĪ, KAUPDAM

Winter-spring annuals. Herbage smooth, the leaves sometimes semi-succulent.

This species has been collected twice in the flora area, 18 years apart, between the lowermost Tinaja and the parking area—the sites most often frequented by visitors. Our observations indicate that it is rather scarce at Tinajas Altas but apparently well established. It is common in nearby northwestern Sonora at waterholes in the Sierra El Pinacate and as a weed in agricultural fields (Felger 2000). The young herbage and especially the seeds are edible. This species, widespread in the New World, is reported as native to the Old World.

Tinajas Altas, disturbed bank, *Van Devender 10 Mar 1980.* Parking area E of Tinajas Altas [Mesa del Muerto], *Felger 98-149.*

Tidestromia lanuginosa (Nutt.) Standl. subsp. **eliassoniana** Sánchez-del Pino & Flores Olvera [*T. eliassoniana* (Sánchez-del Pino & Flores Olvera) Sánchez-del Pino] WOOLLY HONEYSWEET; *HIERBA CENIZA, HIERBA LANUDA*

Summer annuals, generally low and spreading, the herbage often scurfy-whitish; flowers minute, yellow.

Widespread at lower elevations: washes, bajadas, canyons, and sometimes on lower rocky slopes.

Coyote Water, *Felger 04-64.* Tinajas Altas, 19 Mar 1998, *Felger* (observation; dry plants from previous year).

ANACARDIACEAE—CASHEW FAMILY

†**Rhus aromatica** Aiton cf. var. **trilobata** (Nutt.) S. Watson [*R. trilobata* Nutt.] SKUNK BUSH; *LIMITA*

Shrubs with winter-deciduous leaves. Ice Age *Rhus* seeds seem to be from a skunk bush, likely this one. The nearest present-day population occurs on the north side of Pinacate Peak (Felger 2000).

†*R. aromatica* cf. *trilobata*, Tinajas Altas, seeds, 9230–11,040 ybp (5 samples).

Rhus kearneyi F.A. Barkley subsp. **kearneyi** [*Schmaltzia kearneyi* (F.A. Barkley) F.A. Barkley] DESERT SUMAC; *LIMITA DEL DESIERTO.* **Fig. 17.**

Hardwood shrubs, 2–4 m tall, the leaves tough, green, and generally evergreen, or sometimes partially or fully leafless during extreme fore-summer drought. Flowers white or pink; fruits red, about 1 cm long, November–March. The surfaces of freshly ripe fruits are wet with gooey but not sticky exudate; this liquid has a pleasantly tart (acidic) taste. A refreshing, tart drink is made from the fruits. The growth form and habit of this shrub is unique in the region. The type collection is from Tinajas Altas.

Tinajas Altas Mountains, mostly in steep north-facing canyons and cliff bases, from near the lower tinajas to near peak elevations.

This subspecies occurs in the Gila and Tinajas Altas Mountains and in the nearby north-facing, steep granitic mountains in northwestern Sonora west of the Pinacate region (Felger 2000). Disjunct populations of this subspecies occur in the Sierra del Viejo southwest of Caborca, Sonora, and Sierra San Pedro Mártir in Baja California. Two other

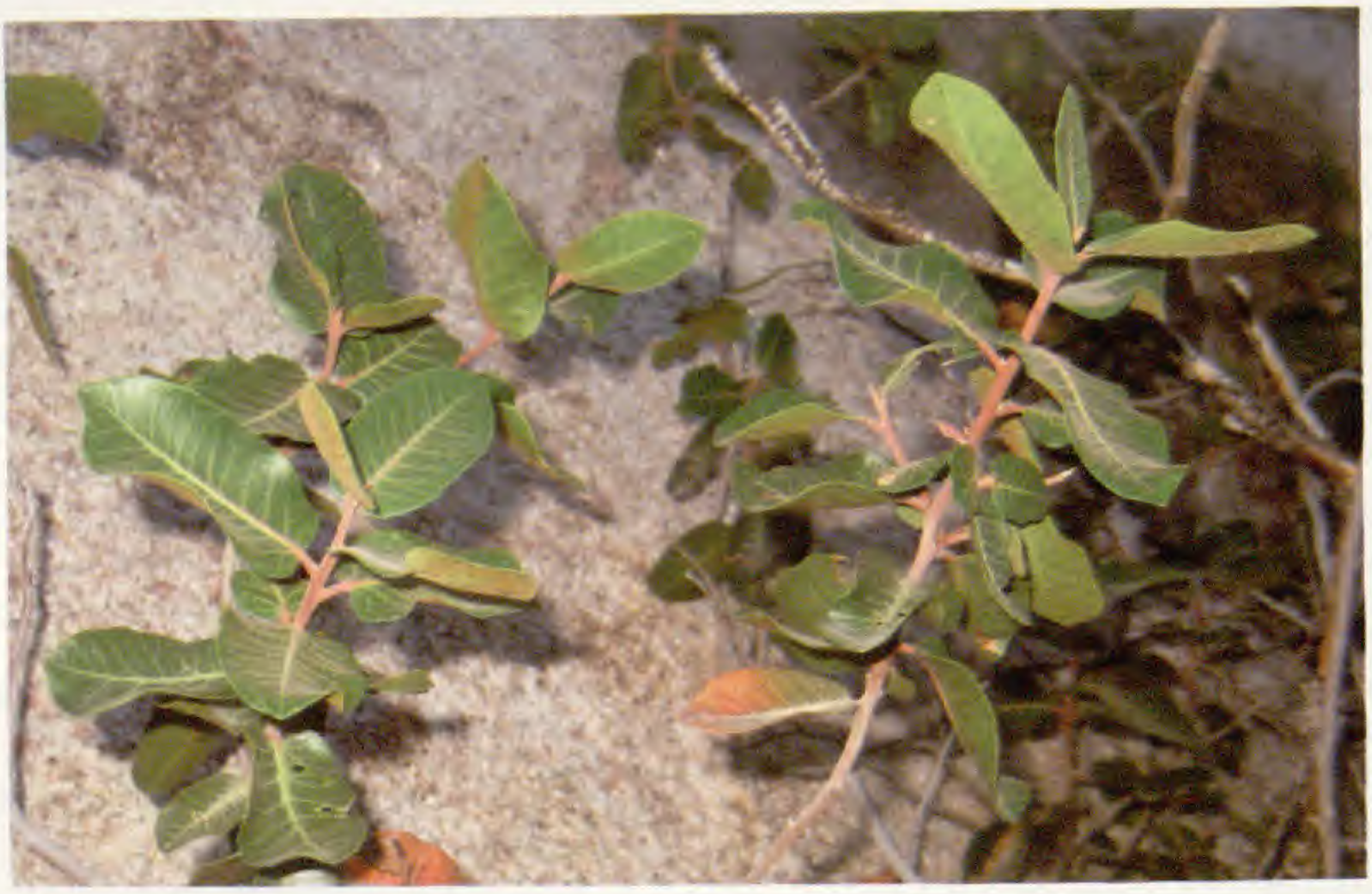

Fig. 17. Desert sumac (*Rhus kearneyi*). North-facing slope at Tinajas Altas. 20 November 2008. Photo by Benjamin T. Wilder.

subspecies occur in mountains of Baja California and Baja California Sur. *Rhus kearneyi* appears to be a relict of a more widespread Pleistocene distribution. This species seems most closely related to *R. integrifolia* (Nutt.) Benth. & Hook. f. ex Rothr. of the Pacific Coast of the Californias; the two species differ in part by leaf shape and pubescence.

Tinajas Altas Mts, [probably at Tinajas Altas], 29 Mar 1930, *Harrison & Kearney 6573* (isotype). Tinajas Altas, *Goldman 2311* (US). NE Tinajas Altas Mts, ca. 500 m SSW of Raven Butte, granitic mountainside, steep NE-facing ravine, shrub to 4 m tall, 488 m, *Morrison 590* (ASU). Borrego Canyon, vicinity of Borrego Tank, *Felger 92-612*.

APIACEAE—CARROT OR PARSLEY FAMILY

†**Daucus pusillus** Michx. WILD CARROT; *ZANAHORIA SILVESTRE*

Cool-season annuals.

Recorded for Tinajas Altas more than nine millennia ago. The nearest present-day records are from the nearby Pinta Sands and Las Playas in Cabeza Prieta Refuge.

†Tinajas Altas, fruits, 8970 & 9790 ybp.

APOCYNACEAE—DOGBANE FAMILY (INCLUDES ASCLEPIADACEAE)

1. Stems erect, not vining ______ **Asclepias**
1. Stems vining or trailing, not self-supporting ______ **Funastrum**

ASCLEPIAS—MILKWEEDS

1. Stems stout and conspicuously leafy; leaves ovate, at least 2 cm wide ______ **A. erosa**
1. Stems slender and reed-like; leaves linear, less than 2 mm wide (leaves quickly deciduous and the stems often leafless).
   2. Stems usually relatively few (or sometimes as many as 50), usually 1.5–3 m tall; flowers 8–9 mm long (including the down-turned petals), the hoods 2–2.5 mm long and not longer than the staminal column (anther head) ______ **A. albicans**
   2. Stems many, usually to 1(–1.5) m tall; flowers 15–20 mm long (including the down-turned petals), the hoods 6–10 mm long and obviously longer than the staminal column ______ **A. subulata**

Asclepias albicans S. Watson. WHITE-STEM MILKWEED; *JUMATE, CANDELILLA*

Shrubs to 3 m tall, the stems reed- or wand-like, generally few, white-waxy, semi-succulent, and often leafless or with few, thread-like leaves. Flowers cream-white.

Fairly common on arid, exposed rock slopes, and occasional on the bajada-plain of the Lechuguilla Valley. This highly xerophytic milkweed has been in the region for at least five millennia. The fruits are edible after being roasted in coals.

Tinajas Altas, *Shreve 5941*. Lechuguilla Valley, *Felger 08-216*. †Tinajas Altas, 1230–5080 ybp.

Asclepias erosa Torr. Giant sand-milkweed, desert milkweed; *hierba del cuervo*

Robust perennials, often 1–1.8 m tall, leaves large and rather thick. Flowers greenish white. Plants often green and flowering in late spring and early summer in amazing heat when nothing else seems alive.

Scattered on sandy soils of Lechuguilla Valley.

Lechuguilla Desert, *Simmons 21 May 1965.*

Asclepias subulata Decne. Desert reed-stem milkweed; *jumete, mata candelilla*

Perennials with many, erect, reed-like stems to about 1 (1.5) m tall. Leaves thread-like, few and quickly deciduous. Flowers waxy, cream- and yellow-white.

Occasional in the Lechuguilla Valley, recorded near the northern boundary of the flora area.

Camino del Diablo, NE of Raven Butte, *Felger 04-3.*

Funastrum hartwegii (Vail) Schltr. [*F. cynanchoides* (Decne.) Schltr. var. *hartwegii* (Vail) Krings. *Sarcostemma cynanchoides* Decne. subsp. *hartwegii* (Vail) R.W. Holm] Climbing milkweed; *güirote*

Perennial vines, sometimes climbing up saguaros and enveloping them. Flowers maroon and white.

Mostly along washes and canyon bottoms. The fresh flowers can be eaten as snacks, and chewing gum was made from the milky sap.

Coyote Water, *Felger 04-46.* Camino del Diablo at Coyote Wash, locally common in mesquites, *Felger 10-163.* Tinajas Altas, *Van Devender 9–10 Mar 1980.*

ASTERACEAE—ASTER OR DAISY FAMILY

This is the largest family in the flora, the Sonoran Desert, and globally. The 43 present-day species represent 19% of the flora—comparable to the 15% of adjacent northwestern Sonora (Felger 2000). Additionally, 8 species are known from the flora area only by fossils. Approximately 22 species, or 58% of the composite species in the flora are annuals or ephemerals, comparable to 52% of adjacent northwestern Sonora; in contrast, worldwide about 25% are annuals. Most of the rest of the local composites are herbaceous perennials or small shrubs, and *Baccharis sarothroides* and *Peucephyllum schottii* are woody shrubs reaching more than 1.5 m in height. Two small composite shrubs form important and widespread components of the local desert vegetation: *Ambrosia dumosa* and *Encelia farinosa*. *Lactuca serriola* and the two *Sonchus* species are the only non-native composites in the flora area.

Most composites in the flora are insect-pollinated. More than 16 species have yellows flowers, e.g., *Baileya pleniradiata*, *Encelia farinosa*, *Gymnosperma glutinosum*, and *Pectis papposa*. *Stephanomeria pauciflora* has nocturnal or crepuscular white or pinkish flowers; whitish flowers are found on about 10 species. A few species have lavender rays but yellow disk flowers, e.g., *Erigeron lobatus* and *Monoptilon bellioides*. There are no red-flowered composites in the region. The Ambrosiinae, e.g., *Ambrosia*, are wind-pollinated, with corollas absent from female flowers and reduced on male flowers. Others, such as the filaginoids *Logfia* and *Stylocline*, have minute, reduced flowers and are undoubtedly selfing.

1. Plants often with milky sap; all florets conspicuous, bisexual, similar in shape (inner florets often smaller) with strap-like or ray-like (ligulate—the ligules 5-lobed) corollas.
  2. Pappus bristles thread-like (capillary), not plumose.
    3. Florets 3 or 4 per head; phyllaries 4–5 mm long **Prenanthella**
    3. Florets many per head; phyllaries 9–13 mm long.
      4. Upper part of plants including involucres with conspicuous tack-shaped glands, otherwise glabrous or nearly so; leaf margins not spinose-toothed; achenes cylindrical, beaked (narrowed to a slender neck just below the pappus) **Calycoseris**
      4. Plants without tack-shaped glands; leaf margins mostly spinose-toothed; achenes flattened, rounded at apex, not beaked **Sonchus**
  2. Pappus bristles plumose.
    5. Heads medium to large, the larger phyllaries (13–)17–22 mm long; ligules of larger (outer) florets usually 15–30 mm long; achenes tapering into a slender beak; pappus bristles (6–)9.5–14 mm long **Rafinesquia**
    5. Heads small, the phyllaries 6–10.5 mm long; ligules 6–12 mm long; achenes columnar (not tapering), ending abruptly (truncate); pappus bristles 2.2–8 mm long **Stephanomeria**
1. Sap not milky; florets conspicuous or not, and not all strictly ligulate; heads with 1) ray and disk florets, the rays sterile or pistillate, usually 3-toothed or 3-lobed, or 2) disk or disk-like florets only, the corollas showy to reduced or lacking (florets sometimes enclosed in burs), or 3) bilabiate (2-lipped) florets only.

6. Shrubs with vegetative parts (herbage and phyllaries) sticky (conspicuously resinous-glutinous) and aromatic (these plants may also key out elsewhere).

7. Monoecious, the florets of each flower head of a single sex, the female flowers enclosed in burs ________ **Ambrosia** (in part)

7. Flower heads unisexual or not, flowers not in burs.

8. Leaves filiform, terete or nearly so, not lobed, less than 2 mm wide .... **Peucephyllum**

8. Leaves not filiform or terete, 2 or more mm wide, or if very narrow then at least some leaves toothed or lobed and the blades flattened or at least not terete.

9. Plants usually less than 1 m tall; flowers bisexual; pappus none; flowers yellow ________ **Gymnosperma**

9. Plants often 1–2 m tall; male and female flowers on separate plants; pappus conspicuous; flowers dull whitish ________ **Baccharis**

6. Herbaceous plants or shrubs; vegetative parts resinous or not.

10. Small shrubs; heads of bilabiate florets only, the flowers yellow; achenes expanded at apex into a disk bearing numerous pappus bristles ________ **Trixis**

10. Shrubs or herbs; heads with ray and disk florets, or only disk or disk-like florets, the florets not bilabiate, the flowers yellow or not; achenes not as above.

11. Heads of disk and ray florets, the rays usually obvious (taxa with small, inconspicuous, or early-deciduous rays will key out in either choice; if in doubt, best to go to 21, heads not unisexual).

12. Pappus none (caution: refers to absence of pappus at top of achene, do not confuse hairs on side of achenes with the pappus).

13. Leaves essentially glabrous (minutely scabrous), usually resinous; flower heads 1.5 mm wide ________ **Gymnosperma**

13. Leaves hairy, not resinous; flowers heads more than 10 mm wide.

14. Annuals; leaves pinnately divided; larger leaves basal or near the base; achenes ribbed, more or less cylindrical, not outlined with hairs ________ **Baileya**

14. Perennial bushes or shrubs; leaves entire or nearly so, mostly at stem tips; achenes flattened and not ribbed, the margins outlined with white hairs ________ **Encelia farinosa**

12. Pappus present, at least on disk achenes.

15. Short-lived perennials and flowering in the first season; plants pubescent with glandular and non-glandular hairs; leaves mostly sessile, entire to deeply divided, the segments mostly spinescent-tipped; flower heads usually 1.5–3.5 cm wide, with ray and disk florets; pappus of slender persistent bristles (or sometimes absent from ray florets) ________ **Xanthisma**

15. Plants not with all of the above features.

16. Annuals or perennials; heads medium-sized to large, usually (2) 3–5 cm wide including rays; receptacles with chaffy bracts subtending and partly enclosing each disk floret.

17. Winter-spring annuals; phyllaries dark green, fringed (ciliate) with long white hairs ________ **Geraea**

17. Small shrubs; phyllaries not fringed with long white hairs ________ **Bahiopsis**

16. Annuals; heads small to medium-sized, mostly less than 2.5 cm wide; receptacles naked, disk florets without subtending bracts.

18. Leaves toothed, lobed, or pinnatifid.

19. Plants with soft, spreading hairs; leaves pinnatifid to pinnately lobed or toothed; rays lavender, filiform, numerous, and disk-like ________ **Erigeron**

19. Plants with short non-spreading hairs or essentially glabrous; leaves palmately toothed or lobed; rays white, linear but not filiform, one dozen or fewer, and not disk-like ________ **Perityle**

18. Leaves entire or entire with bristles at base.

20. Plants glabrous, dotted with conspicuous oil glands; leaves with prominent marginal bristles near the leaf base; rays yellow ________ **Pectis**

20. Plants pubescent, without oil glands; leaves without bristles; rays whitish or lavender ________ **Monoptilon**

11. Heads of disk florets only, outer florets without an obvious ligule or ray, or if ray florets present then disk-like (inconspicuous or reduced, or lacking a well-developed ligule—eligulate; if in doubt about presence of rays then take this choice).

21. Heads unisexual, the female florets enclosed in a bur or woody, winged bur-like involucre ________ **Ambrosia**

21. Heads not unisexual, the female florets not enclosed in burs.

22. Plants tomentose or white-woolly; winter-spring annuals (or rarely persisting through the summer in *Trichoptilium*).

23. Stems thick; leaves obviously petioled, the blades as wide or wider than long ________ **Psathyrotes**

23. Stems not notably thick; leaves sessile or the petioles inconspicuous or short and winged, the blades longer than wide.

24. Leaves coarsely toothed; individual flowers small but readily visible, bright yellow; achenes more than 2 mm long ________ **Trichoptilium**

24. Leaves entire; individual flowers minute, inconspicuous and dull-colored; achenes 1 mm or less in length ("fuzzy little composites" including filaginoids).

25. Disk florets all bisexual, the disk achenes usually developing and with copious pappus (averaging more than 12 bristles per floret); receptacle often tack-shaped ________ **Logfia**

25. Disk florets all staminate, the disk achenes not developing and their pappus none or vestigial (averaging less than 12 bristles); receptacle often conical or cylindrical ________ **Stylocline**

22. Plants glabrous or hairy but not woolly.

26. Shrubs; florets subtended by chaffy bracts of receptacle, the bracts folded around the achenes and falling with them.

27. Leaves opposite, or the upper ones alternate; achenes 2.8–4 mm long, the margins not different from the body; pappus present (rays present but often falling early) **Bahiopsis**

27. Leaves alternate; achenes 7–10 mm long, the margins with long white hairs; pappus none **Encelia frutescens**

26. Annuals or perennials, herbaceous to shrubby; receptacle naked, without chaffy bracts.

28. Plants glaucous and pungently aromatic, the leaves and bracts with conspicuous, elongated oil glands; flowers whitish or pinkish **Porophyllum**

28. Plants not glaucous, without oil glands, not pungently aromatic.

29. Perennial bushes; pappus of plumose (feathery) bristles **Bebbia**

29. Annuals and perennials (some bushes); pappus not plumose.

30. Annuals.

31. Spring annuals; leaves 1–3-times pinnatisect (pinnately divided to the midrib) **Chaenactis**

31. Leaves entire or margins lobed or parted halfway or less to midrib.

32. Leaf surfaces mostly grayish or grayish green with coarse, stiff grayish or white hairs; achenes at least 4 mm long **Palafoxia**

32. Leaf surfaces usually green; glabrous or the hairs not coarse and stiff; achenes 3.2 mm or less in length.

33. Delicate spring annuals; leaves very thin, almost membranous; flowers yellow; phyllaries 6–7.5 mm long; achenes 2.8–3.2 mm long; pappus bristles capillary (soft and not barbellate) **Senecio mohavensis**

33. Annuals, mostly robust and not delicate; leaves not notably thin; flowers whitish; phyllaries 2.5–3.5 mm long; achenes 0.8–1.3 mm long; pappus bristles barbellate **Laennecia**

30. Shrubby or bushy perennials (or dwarf shrubs or subshrubs), the vegetative parts mostly present all year.

34. Leaves petioled, junction of blade and petiole abrupt and well marked, the blades spinose-toothed **Brickellia atractyloides**

34. Leaves sessile or the blade gradually narrowed to an indistinct petiole less than ⅙ as long as the blade, the blade entire to toothed but not spinose.

35. Leaves conspicuously resinous and densely crowded at stems tips (internodes scarcely discernable); flower heads sessile, mostly solitary at stem tips; phyllaries similar in size in an inner series, plus an outer series of few, narrower and sometimes shorter phyllaries; flowers bright yellow **Peucephyllum**

35. Leaves not resinous (or not conspicuously so) and not crowded, the internodes apparent; flower heads stalked; phyllaries conspicuously graduated; flowers whitish to lavender or pale yellow.

36. Herbage densely pubescent with stalked glandular hairs; leaves with a long, slender petiole and an arrow-shaped blade sometimes greatly reduced and indistinct; flower heads bisexual **Pleurocoronis pluriseta**

36. Herbage yellow-green to glaucous, essentially glabrous or with short, inconspicuous hairs; leaves sessile, linear to lanceolate; flower heads unisexual (male and female flowers on separate plants) **Baccharis**

AMBROSIA—Bur sage, ragweed

Perennial herbs or shrubs; flowers inconspicuous and wind pollinated, the heads unisexual with disk florets, the male flowers producing large quantities of hay fever-causing pollen, the female flowers enclosed in burs.

1. Leaves and leaf segments thread-like (filiform), less than 2 mm wide; burs with flat wings narrowed basally **A. salsola**

1. Leaves and leaf segments not filiform, more than 4 mm wide; burs with straight or hooked spines widest at base.

2. Leaves pinnately to tri-pinnately deeply dissected **A. dumosa**

2. Leaf margins toothed or rarely nearly entire, not deeply dissected.

3. Leaves sessile, firm, with spine-tipped teeth **A. ilicifolia**

3. Leaves petioled, "soft," and flexible; marginal teeth, if present, not spine-tipped.

4. Shrubs with erect, few-branched stems to 1 m or tall; leaf blades more than 7 cm long; burs with hooked spines **A. ambrosioides**

4. Subshrubs usually less than 0.8 m tall with branched stems; leaf blades less than 5 (6.5) cm long; burs with straight spines (rarely a few hooked spines near apex) **A. deltoidea**

Ambrosia ambrosioides (Cav.) W.W. Payne [*Franseria ambrosioides* Cav.] Canyon ragweed; *chicura*; ñuñuvĭ jej

Shrubs with slender stems and large, elongated, triangular and glandular leaves. Male flowers yellow, female flowers and seeds in large burs.

Growing with warm weather, the herbage frost-sensitive. Washes and canyon bottoms. This species is an important medicinal plant (Felger 2007).

Tinajas Altas, *Van Devender 9–10 Mar 1980.* Coyote Wash, 10 Jan 2002, *Felger* (observation).

†**Ambrosia confertiflora** DC. SLIMLEAF BUR-SAGE; *ESTAFIATE*; MOʼOSTALK

Herbaceous perennials, winter and spring dormant.

Not known from the Tinajas Altas area today, but it was in the Butler Mountains more than 10,000 years ago. The nearest present-day records are from nearby areas in Cabeza Prieta Refuge in poorly drained, clayish soils of the large playas.

†Butler Mts, bur, 10,360 ybp.

Ambrosia deltoidea (Torr.) W.W. Payne [*Franseria deltoidea* Torr.] TRIANGLE-LEAF BUR-SAGE; *CHAMIZO FORRAJERO*; TADSAD, VA:GITA

Bushy subshrubs; tardily drought-deciduous and summer dormant. Flowers green or yellow, inconspicuous; seeds in small burs.

This species occurs just east of the study area, where it is one of the most widespread and abundant perennials in the region. However, in the more xeric Tinajas Altas region it is replaced by *A. dumosa.* A single Tinajas Altas collection in 1983 is an interesting anomaly, although tellingly, it is noted as being "rare." In nearby regions, such as northwestern Sonora, *A. deltoidea* does not extend into such extremely xeric areas as does *A. dumosa* (Felger 2000).

Tinajas Altas Mountains, Tinajas Altas, 1200 ft, rare on granite, 0.5 m shrub, *Van Devender 26 Mar 1983.*

Ambrosia dumosa (A. Gray) W.W. Payne [*Franseria dumosa* A. Gray] WHITE BUR-SAGE; *CHAMIZO*; TADSAD

Dwarf shrubs, the herbage often whitish. Summer dormant, flowering and fruiting fall to spring; seeds in small burs. In late March, 2010, our shoes and lower pant legs were coated yellow with white bursage pollen.

Valley plains, bajadas, and rocky slopes to higher elevations, and extending into the harshest, driest sites. White bursage is one of the most widespread and common perennials in the flora area as well as across much of the Sonoran and Mojave deserts. It has been in the flora area for more than 15,700 years.

SE of Raven Butte, bajada, *Felger 04-7.* Tinajas Altas, *Felger 10-177.* Tinajas Altas Pass, *Reeves R5398* (ASU). †Tinajas Altas, leaves, burs, 1230–15,680 ybp (11 samples).

Ambrosia dumosa × A. ilicifolia

This putative hybrid appears intermediate between the presumed parents, both of which were present. Only one plant of the presumed hybrid was seen in the flora area.

Tinajas Altas, steep slope N of the tinajas, two branches collected from the one plant seen, *Felger 98-136.*

Ambrosia ilicifolia (A. Gray) W.W. Payne [*Franseria ilicifolia* A. Gray] HOLLY-LEAF BUR-SAGE

Broad, spreading shrubs, often 1–2+ m wide. Leaves firm and holly-like, the dead leaves persistent. Summer dormant; flowering and fruiting winter and spring. Seeds in burs.

Washes, canyon bottoms, and sometimes on rocky slopes. The dry, dead leaves rustling in the wind may sound startlingly like a rattlesnake. Its presence at Tinajas Altas dates from more than 15,700 years ago.

Tinajas Altas, *Vorhies 16 Apr 1924.* 1.7 km WNW of Tinajas Altas Peak, 340 m, *Baker 13308* (ASU). Frontera Canyon, 18 Mar 1998, *Felger* (observation). †Tinajas Altas, leaves, burs, 1230–15,680 ybp (17 samples).

Ambrosia salsola (Torr. & A. Gray) Strother & B.G. Baldwin var. **pentalepis** (Rydb.) Strother & B.G. Baldwin [*Hymenoclea salsola* Torr. & A. Gray var. *pentalepis* (Rydb.) L.D. Benson] WHITE BURROBUSH, CHEESEBUSH; ʼI:WADHOD

Shrubs, usually about as wide as tall, with many spreading and interlacing branches. Flowers straw-colored, the female flowers and seeds in small, winged burs. Flowering March and April; the wet plants smell like a dead animal.

Widespread across much of the Lechuguilla Valley and canyons in the mountains, and present in the region at least 9000 years ago.

Camino del Diablo at Coyote Wash, *Felger 10-166.* Coyote Water, 18 Mar 1998, *Felger* (observation). Tinajas Altas: 1200 ft, *Lindquist 26 Mar 1983*; *Webster 24245.* †Butler Mts, bur, 8570 ybp. †Tinajas Altas, burs, 8970 ybp.

†**Artemisia ludoviciana** Nutt. subsp. **albula** (Wooton) D.D. Keck. WESTERN MUGWEED, WHITE SAGE, SILVER WORMWOOD; *ESTAFIATE*

Herbaceous perennials, flowering in late spring and probably with summer rains.

Western mugweed was at Tinajas Altas from at least 11,000 to more than 18,700 years ago. The nearest present-day records are from mountains in Organ Pipe Monument and higher elevations in the Sierra Pinacate.

†Tinajas Altas, leaf fragments, 11,040–18,700 ybp (4 samples).

BACCHARIS

Shrubs with resinous herbage. Male and female flowers on separate plants; flower heads of disk florets.

1. Shrubs usually low and broader than tall, the stems not broom-like, the herbage not yellow-green and not glutinous, the twigs brown; leaves entire; achenes 5-ribbed ____ **B. brachyphylla**
1. Shrubs usually taller than wide, the stems broom-like, the herbage yellow-green and glutinous-sticky, the twigs green; leaves mostly linear, the larger leaves often minutely toothed (denticulate); achenes 10-ribbed ____ **B. sarothroides**

Baccharis brachyphylla A. Gray. SHORT-LEAF BACCHARIS

Low, spreading shrubs. Flowers inconspicuous; mostly late spring to early fall.

Mostly along canyon bottom and at higher elevations in the Tinajas Altas Mountains; localized and not common.

Tinajas Altas, *Goodding 1186.* Tinajas Altas Canyon, *Felger 04-79.* Frontera Canyon, canyon bottom among rocks, *Felger 98-108.*

Baccharis sarothroides A. Gray. DESERT BROOM; *ESCOBA AMARGA, ROMERILLO*; SUSK KUAGIG

Broom-like shrubs; branches green, mostly leafless or sparsely leaved. Flowers whitish, the fruits become airborne with copious white pappus; flowering and fruiting mostly October and November.

Localized along Coyote Wash; not common.

Coyote Water, *Felger 04-26, 04-27.*

Bahiopsis parishii (Greene) E.E. Schill. & Panero [*Viguiera parishii* Greene. *V. deltoidea* A. Gray var. *parishii* (Greene) Vasey & Rose] PARISH'S GOLDENEYE; *ARIOSA*

Small shrubs; stems slender and brittle, the leaves rough-surfaced (scabrous). Flower heads with bright yellow ray and disk florets.

Canyons and slopes to the summit.

Tinajas Altas, 990 m, *Felger 04-84.* Borrego Canyon, 3 Feb 1990, *Felger* (observation).

Baileya pleniradiata Harv. & A. Gray. WOOLLY DESERT-MARIGOLD

Non-seasonal annuals, but mostly in spring. Flowers yellow and showy.

Sandy soils; washes, bajadas, valley plains, and canyons at lower elevations.

W side of Tinajas Altas Mts, *Felger 05-48.* Frontera Canyon, Mexico border, 18 Mar 1998, *Felger* (observation). Butler Mts, *Van Devender 27 Mar 1983.*

Bebbia juncea (Benth.) Greene var. **aspera** Greene. SWEETBUSH, CHUCKWALLA DELIGHT; HAUK 'U'US

Globose, bushy perennials or shrubs with slender stems and rough (scabrous) herbage; foliate sparse, the leaves quickly drought deciduous. Flowers heads yellow and fragrant, with disk florets only, attracting numerous butterflies and many other insects; flowering response non-seasonal. Karen Reichhardt (personal communication 21 February 2005) has observed chuckwallas (*Sauromalus ater*) at Tinajas Altas eating chuckwalla delight.

Common and widespread; bajadas, washes (Fig. 15), canyons, and rocky slopes. Present in the region for at least 10,800 years.

Camino del Diablo, SE of Raven Butte, *Felger 04-6.* Tinajas Altas Pass, *Reeves R-5411* (ASU). †Butler Mts, achenes, 8160 ybp. †Tinajas Altas, achenes, 4010–10,750 ybp (8 samples).

Brickellia atractyloides A. Gray var. **atractyloides.** SPINY-LEAF BRICKELLBUSH

Subshrubs or small bushy perennials. Leaves firm with spinescent marginal teeth. Flowers pale yellow and purplish; February and March.

Rocky slopes, mostly north facing, and in canyons. It has been in the Tinajas Altas Mountains for more than 15,700 years.

Borrego Canyon, N-facing slope, *Felger 90-7.* Tinajas Altas, *Vorhies 16 Apr 1924.* †Tinajas Altas, leaves, involucres, achenes, 4010–15,680 ybp (13 samples).

†**Brickellia coulteri** A. Gray var. **coulteri.** TRIANGLE-LEAF BRICKELLBUSH; *PACHABA*

Small shrubs. It was at Tinajas Altas more than 4500 years ago. The nearest known present-day records are in the eastern part of Cabeza Prieta Refuge and the Sierra Pinacate.

†Tinajas Altas, twigs, involucres, 4490 & 10,950 ybp.

†**Calycoseris parryi** A. Gray. YELLOW TACK-STEM

Cool-season annuals. Flowers pale yellow.

It was at Tinajas Altas more than 9 millennia ago. The nearest present-day population occurs in the Sierra Pinacate above 550 m.

†Tinajas Altas, achenes, 9230 & 9900 ybp.

Calycoseris wrightii A. Gray. White tack-stem

Cool-season annuals with milky sap, branched at or near the base, and with conspicuous tack-shaped glandular hairs above, otherwise glabrous or glabrate. Rays of flower heads white with pinkish brown streaks (drying purple-brown) on the lower surfaces.

Widely scattered, recorded from Coyote Wash and Surveyors Canyon.

Coyote Water, 21 Feb 2005, *Felger 05-145*. Surveyors Canyon, canyon bottom below Surveyors Tank, 29 Mar 2010, *Felger* (observation).

CHAENACTIS

Spring annuals; flower heads of disk florets, white and often suffused with pink.

1. Stems with short white hairs, not cobwebby; phyllaries with an elongated slender (terete) tip; heads with stout receptacular bristles among the florets; pappus scales 1–3 mm long _____ **C. carphoclinia**

1. Herbage with cobweb-like woolly hairs; phyllary tips blunt; receptacular bristles none; pappus scales 3.5–6.5 mm long _____ **C. stevioides**

Chaenactis carphoclinia A. Gray var. **carphoclinia.** Pebble pincushion

Foliage not cobwebby, the phyllary tips needle-like. Flowers white.

Sandy flats, washes, bajadas, and rocky slopes.

Tinajas Altas, *Van Devender 26 Mar 1983.*

Chaenactis stevioides Hook. & Arn. Desert pincushion

Plants generally slightly more robust than those of *C. carphoclinia*; stem base often with at least some cobwebby hairs; phyllary tips relatively blunt. Flowers white or pinkish white.

Sandy soils of valley bottoms and rocky slopes. It has been in the region for at least 10,000 years.

Coyote Water, 18 Mar 1998, *Felger* (observation). W side of Tinajas Altas Pass, *Lindquist 26 Mar 1983.* †Tinajas Altas, achenes, 9900 ybp.

ENCELIA

Small shrubs, the leaves alternate, and with yellow flowers, and sometimes with brownish disk florets.

1. Leaves and stem tips white-woolly; leaves mostly 3–10 cm long, 1.5–3.5 cm wide; heads usually several or more in broad panicles, the peduncles essentially glabrous; rays well developed _____ **E. farinosa**

1. Leaves and stems rough-haired (scabrous), not woolly; leaves mostly 2–3 cm long, 0.35–0.6 (1.0) cm wide; heads mostly solitary, the peduncles hairy; rays none _____ **E. frutescens**

Encelia farinosa A. Gray ex Torr. var. **farinosa**. Brittlebush; *incienso, hierba del bazo, rama blanca*; tohaves. **Figs. 8 and 9.**

Shrubs, not long-lived. Leaves highly variable with soil moisture. Flowering branches usually raised well above the foliage; massive displays of daisy-like flowers with bright yellow rays and yellow or brownish disk florets, mostly in spring but also with summer-fall rains. At maturity the flower heads turn downward, dumping out the seeds.

One of the most common desert perennials in the region; widespread including all slope exposures to summits, dry washes, canyons, and bajadas; generally not in open creosotebush flats. The yellowish resin was used as chewing gum and an all-purpose adhesive and sealant. Brittlebush has been in the region for at least 43,000 years.

Tinajas Altas, 5 Dec 1935, *Goodding 2204*. El Camino del Diablo, E of Raven Butte, *Felger 01-586*. †Tinajas Altas, leaf fragments, achenes, 1230–18,700 (19 samples), & >4300 ybp.

Encelia farinosa var. **farinosa × E. frutescens**

Putative hybrid. Small shrubs. Leaves intermediate in shape from the presumed parent species. Flower heads bear bright yellow rays and disk florets

Scattered, isolated plants in the Lechuguilla Valley.

Camino del Diablo, E of Raven Butte, *Felger 01-585.*

Encelia frutescens A. Gray. Button encelia

Short-lived shrubs, densely branched and often mound-shaped to about 1 m tall. Flowers heads yellow, of disk florets only; reproductive during warmer months.

Locally common on sandy soils of Lechuguilla Valley.

Coyote Water, *Felger 04-65.* Camino del Diablo at W boundary of Cabeza Prieta, *Felger 10-159.*

†**Ericameria cuneata** (A. Gray) McClatchie var. **spathulata** (A. Gray) H.M. Hall [*Haplopappus cuneatus* A. Gray unrnanked *spathulata* (A. Gray) S.F. Blake] WEDGE-LEAF GOLDENBUSH

Perennial herbs or subshrubs.

The nearest present-day population is in the Ajo Mountains, mostly at higher elevations. It was widespread in the region during the Ice Age.

†Tinajas Altas, leaves, 8970–15,680 (4 samples), & >43,000 ybp.

†**Ericameria laricifolia** (A. Gray) Shinners [*Haplopappus laricifolius* A. Gray] TURPENTINE BUSH

Shrubs with bright green, resinous foliage.

The nearest present-day population is in the Ajo Mountains, mostly at higher elevations. It seems to have been very common and ranged across the region during the late Wisconsin Ice Age.

†Butler Mts, twigs, leaves, involucres, 10,360 ybp (common in this sample). †Tinajas Altas, leaves, 8970–18,700 ybp (10 samples).

†**Ericameria teretifolia** (Durand & Hilg.) Jeps. [*Chrysothamnus teretifolius* (Durand & Hilg.) H.M. Hall] GREEN RABBITBUSH

Small shrubs. It was at Tinajas Altas from 15 to at least 43 millennia ago. The nearest present-day populations are in northwestern Arizona; also in the Mojave Desert in southern California at the western edge of the desert into southern Nevada and southwestern Utah at the upper limits of desert and extending into pinyon-juniper vegetation.

†Tinajas Altas, leaves, involucres, 15,050–18,700 & >43,000 ybp (4 samples).

Erigeron lobatus A. Nelson. DESERT FLEABANE

Spring annuals and sometimes also in summer. Disk florets yellow, the rays very slender and pale lavender.

Scattered along Coyote Wash.

Coyote Water, *Felger 98-118.*

Filago, see **Logfia**

Geraea canescens Torr. & A. Gray. DESERT SUNFLOWER, DESERT GOLD

Coarse spring annuals; showy sunflower-like heads with yellow-orange disk florets and large, bright yellow rays.

Surprisingly, it has not been found in the immediate Tinajas Altas area, although it is often abundant nearby on sandy to gravelly and rocky soils. It has been in the region for at least 9 millennia.

Butler Mts, *Van Devender 27 Mar 1983.* †Butler Mts, achenes, 3820 & 8570 ybp.

Gymnosperma glutinosum (Spreng.) Less. [*Selloa glutinosa* Spreng.] GUMHEAD

Small shrubs or subshrub perennials with resinous herbage. Flowers heads small, with bright yellow disk and disk-like ray florets; flowering during the warmer months.

Widely scattered, seldom common, mostly on rocky slopes and mountain arroyos or canyons.

The plants are amazingly drought resistant and often retain bright green foliage and may even produce some flowers during extended drought when nearly all of the surrounding plants are dormant and leafless. It has been in the flora area for more than 15,700 years.

Tinajas Altas, *McLaughlin 1969.* Surveyors Canyon, canyon bottom, *Felger 10-208.* †Tinajas Altas, involucres, achenes, 1230–15,680 ybp (10 samples).

†**Heterotheca** sp. CAMPHORWEED

An unidentified camphorweed grew at Tinajas Altas until about 4000 years ago. This is the only record for this genus in the flora area and no other members of this large genus presently occur in the region. The nearest population of a member of this genus is *H. sessiliflora* (Nutt.) Shinners var. *thiniicola* (Rzed. & C. Ezcurra) G.L. Nesom, a rare dune endemic of northwestern Sonora (Felger 2000). The Tinajas Altas camphorweed probably was a different species.

†Tinajas Altas, achenes, 4010 to >43,000 ybp (13 samples).

Hymenoclea salsola, see **Ambrosia salsola**

***Lactuca serriola** L. PRICKLY LETTUCE, COMPASS PLANT

Annuals, often germinating in late winter or spring. Highly variable in size; first leaves in a basal rosette, the stem leaves turned basally to hold the leaf edgewise and upright in a north-south plane, hence the name "compass plant." Flowering late spring and summer; flowers pale yellow.

Locally at the south end of Coyote Wash in the Lechuguilla Valley. Usually a weedy species, native to the Old World.

Camino del Diablo at Coyote Wash, locally abundant in mesquite "forest," some dry dead stalks from last year reach 2+ m in height, *Felger 10-162.*

Laennecia coulteri (A. Gray) G.L. Nesom [*Conyza coulteri* A. Gray] COULTER'S HORSEWEED

Warm-weather annuals; flowers inconspicuous. Infrequent along Coyote Wash.

Coyote Wash at Camino del Diablo, *Felger 02-14.*

LOGFIA. FLUFFWEED

Diminutive or small spring annuals, often white-woolly. Flowers minute. *Logfia* is a genus segregated from *Filago.*

1. Branching pattern usually symmetric (2 equal side-branches at each stem nodes, "pseudo-dichotomous"), the plants generally as broad or broader than tall; flower heads and leaves mostly restricted to the branch nodes (forks); leaves nearly linear, usually much longer than the heads; florets inside innermost chaff bracts 4–12, the minority of them (0–2) pistillate _______ **L. arizonica**
1. Branching pattern usually asymmetric (irregular); well-developed plants often erect and taller than wide, and often branched from a dominant central stem; flower heads and leaves more or less evenly distributed; leaves mostly oblanceolate, acute, usually not much longer than the heads; florets inside innermost chaff bracts 12–40, the minority (3–7) bisexual _______ **L. filaginoides**

Logfia arizonica (A. Gray) Holub [*Filago arizonica* A. Gray] ARIZONA FLUFFWEED

Small cool-season annuals, often white-woolly; branching pattern usually symmetric (2 equal side-branches at each node, "pseudo-dichotomous").

Sandy, gravelly or clayish-silt soils; washes, canyon bottoms, floodplains, and bajadas and perhaps soil pockets on rocky slopes. Often where rainwater may briefly accumulate. Commonly growing intermixed with *L. filaginoides.*

Camino del Diablo at Coyote Wash, *Felger 02-9.* Coyote Water, *Felger 98-114.* Surveyors Canyon, canyon bottom, *Felger 10-212.*

Logfia filaginoides (Hook. & Arn.) Morefield [*L. californica* (Nutt.) Holub. *Filago californica* Nutt.] CALIFORNIA FLUFFWEED

Small, cool-season annuals, often white-woolly; characteristically slender with erect stems. Innermost (disk) achenes mostly sparsely papillate, with a pappus of 17–23 bristles falling away in complete or partial rings; lobes of disk corollas mostly 4, usually red-tipped.

Washes and canyons, bajadas, and among rocks on slopes.

Tinajas Altas, *Felger 98-144.* Surveyors Canyon, canyon bottom, *Felger 10-213.* Canyon below Raven Butte Tank, *Felger 10-234.*

Machaeranthera pinnatifida, see **Xanthisma spinulosus**

Monoptilon bellioides (A. Gray) H.M. Hall. MOJAVE DESERT STAR

Low growing cool-season annuals. Flower heads showy, the rays white or lavender, curling in (inrolling) with age, the disk yellow; pappus bristles of shorter, outer white bristly scales, and more numerous inner straw-colored bristles.

Seasonally common, sometimes producing showy displays on otherwise nearly barren gravelly-rocky flats; sandy to rocky soils, washes, bajadas, desert pavements, canyons, and sometimes on lower slopes.

N of Tinajas Altas Pass, *Halse 31 Mar 1973.* Tinajas Altas Pass, *Reeves 5399* (ASU). Surveyors Canyon, canyon bottom, *Felger 10-215.* Tinajas Altas Canyon, 19 Mar 1998, *Felger* (observation).

Palafoxia arida B.L. Turner & M.I. Morris var. **arida.** SPANISH NEEDLES

Spring annuals and sometimes germinating and flowering with summer-fall rains; usually erect, silvery-haired, and the leaves linear. Flower heads of disk florets, dull white or pale pink.

Not recorded from the immediate Tinajas Altas area but common in the western Cabeza Prieta Refuge and near the Butler Mountains.

Butler Mts, sand dune, *Van Devender 27 Mar 1983.*

Pectis papposa Harv. & A. Gray var. **papposa.** DESERT CHINCHWEED; *MANZANILLA DEL COYOTE*; BAN MANZANI:YA

One of the most abundant summer-fall annual wildflowers in the region. Plants pungently aromatic with conspicuous oil glands. Flowers showy and bright yellow with ray and disk florets.

Sandy to rocky soils, washes, plains, and less common on slopes.

Coyote Wash at Camino del Diablo, *Felger 04-66.* Coyote Water, *Felger 04-56.*

Perityle emoryi Torr. DESERT ROCK DAISY

Cool-weather annuals. Flower heads with white rays and yellow disk florets.

Seasonally common; sandy to rocky soils, washes, plains, and slopes. Documented for the region between 9200 and 11,000 years ago.

Coyote Water, *Felger 04-57.* Canyon below Raven Butte Tank, *Felger 10-237.* Tinajas Altas Mts at Mexico border, 18 Mar 1998, *Felger* (observation). Canyon above the Tinajas, 21 Nov 2008, *Felger* (observation). †Tinajas Altas, achenes, 9230 & 10,950 ybp.

Peucephyllum schottii A. Gray. PYGMY-CEDAR; *ROMERO DEL DESIERTO*

Woody shrubs often 1–2+ m tall, resembling a small conifer, with twisted trunks and branches, and shredding bark. Herbage resinous. Flowers fragrant, of yellow disk florets.

Rocky and often exposed mountain slopes and in the region for more than 15,700 years.

S of Tinajas Altas, N-facing slope, 8 ft tall, 7–8 ft wide, *Hodgson 2096* (DES). Tinajas Altas, *Van Devender 5 Mar 1983.* Frontera Canyon, 18 Mar 1998, *Felger* (observation). †Butler Mts, achenes, 740–11,060 ybp (5 samples). †Tinajas Altas, leaves, involucres, achenes, 1230–15,680 ybp (6 samples).

Pleurocoronis pluriseta (A. Gray) R.M. King & H. Rob. [*Hofmeisteria pluriseta* A. Gray] ARROW-LEAF

Small shrubs or subshrubs. Leaf blades very narrowly arrow-shaped, longer than wide, and during drought the blades often scarcely wider than the petiole.

Often growing from crevices on rock faces, canyons, cliffs, and slopes.

Tinajas Altas Mtn, on cliffs and rock slopes, 4 Mar 1927, *Belden 3604.* Tinajas Altas Tanks, on rocky hills above tanks, *McManus 669.*

†Pleurocoronis sp./spp.

The younger specimens are probably *P. pluriseta.* The older ones may be *P. laphamioides* (Rose) R.M. King & H. Rob., which nowadays occurs in the Ajo Mountains and farther south in northwestern Mexico.

†Butler Mts, involucres, achenes, 740–11,250 ybp (7 samples). †Tinajas Altas, involucres, achenes, 4010–15,680 ybp (9 samples).

Porophyllum gracile Benth. SLENDER PORELEAF; *ODORA, HIERBA DEL VENADO*

Herbaceous perennials, pungently aromatic. Stems and leaves bluish green, the foliage sparse and quickly deciduous, the leaves slender. Flower heads with pinkish-white disk florets. Growing and flowering at various seasons.

Widely scattered; rocky slopes, canyons, arroyos, and upper bajadas. It has been in the region since at least 8600 years ago.

Tinajas Altas, *Van Devender 5 Mar 1983.* Tinajas Altas Canyon, 19 Mar 1998, *Felger* (observation). †Butler Mts, achenes, involucres, 740–8570 ybp (4 samples). †Tinajas Altas, involucres, achenes, 1230–8255 ybp (3 samples).

Prenanthella exigua (A. Gray) Rydb. BRIGHTWHITE

Diminutive spring annuals. Flower heads 5 mm long, with 3 or 4 ray florets, the rays white with violet tips.

Higher elevations in the mountains.

Tinajas Altas, above the tinajas, *Felger 98-132.*

Psathyrotes ramosissima (Torr.) A. Gray. DESERT VELVET, TURTLEBACK

Spring annuals, compact, woolly, and strongly scented. Leaves velvety gray-green with deeply incised veins. Flower heads of yellow disk florets. Achene hairs and pappus bristles bright, iridescent copper-colored.

Apparently highly localized at the north end of the Tinajas Altas region and the desert plains west of the Tinajas Altas range, observed on a steep granitic slope where it was uncommon and on a cobble-rock bajada.

Camino del Diablo, E edge of Davis Plains, *Halse 31 Mar 1973* (probably slightly north of the flora area). Along the "old" Tinajas Altas Pass road (a bit north of the present Tinajas Altas Pass road), 7 72 843 E, 35 81 704 N, Zone 11, WGS 84, 1050 ft, common, photo, *Malusa 18 April 2011.*

Rafinesquia neomexicana A. Gray. Desert chicory

Cool-season annuals; plants glabrous (as opposed to *Calycoseris wrightii*), the flower heads showy, of ray-like florets, white tinged with pale rose-purple and yellow. Plants often browsed and growing in the protection of small shrubs, the flowering stems overtopping the nurse shrub such as *Ambrosia dumosa* or, especially in drier years, spiny shrubs.

Sandy to rocky soils; washes, plains, and slopes, lowlands to higher elevations. Present at Tinajas Altas more than 10,000 years ago.

Coyote Water, *Felger 05-151*. Tinajas Altas Pass, along wash, *McLaughlin 1974*. †Tinajas Altas, achenes, 10,070 ybp.

Senecio mohavensis A. Gray. Mojave groundsel

Winter-spring annuals, often small and delicate. Stems and lower leaves glabrous and often purple-green; flowers yellow, rather inconspicuous, rays none or sometimes inconspicuous and several mm long.

Often in protected, shaded places, among rocks in mountain canyons and on north-facing slopes.

Tinajas Altas, *Van Devender 26 Mar 1983*. Tinajas Altas Canyon, 19 Mar 1998, *Felger* (observation).

***SONCHUS.** Sow thistle

Winter-spring annuals, the flower heads pale yellow with ray-like (ligulate) florets.

1. Stems sometimes more than 1 m tall; plants usually conspicuously spinescent; achenes smooth between ribs, the margins thin and wing-like, the ribs not knobby ______ **S. asper**
1. Stems seldom reaching 1 m; plants not conspicuously spinescent; mature achenes wrinkled and roughened between the ribs (caution: refers to mature achenes), the ribs themselves are transversally knobby, the margins not thin and wing-like ______ **S. oleraceus**

***Sonchus asper** (L.) Hill subsp. **asper.** Prickly sow thistle; *chinita*; ho'idkam, 'i:vakĭ

Winter-spring annuals; larger plants conspicuously spiny-prickly and sometimes robust.

Localized and seldom common; documented at two localities near the Mexican border—in a wash and a canyon bottom. The nearest known localities are waterholes and canyon bottoms in the vicinity of Quitobaquito at Organ Pipe Monument (Felger 2000).

Coyote Wash at Camino del Diablo, *Felger 02-10*. Frontera Canyon, 18 Mar 1998, *Felger* (observation).

***Sonchus oleraceus** L. Common sow thistle; *chinita*; hauvĭ, hehewo

Winter-spring annuals, mostly less than 80 cm tall.

Widely scattered but not common; washes and canyons, sometimes on slopes. This sow thistle is well established in the flora area.

Frontera Canyon, 18 Mar 1998, *Felger* (observation).

Stephanomeria pauciflora (Torr.) A. Nelson. Desert-straw, desert wire-lettuce

Globose or mound-shaped bushy perennials with sparse foliage. Flowers pale pink, closing by mid-day or earlier in hot weather; flowering non-seasonally.

Washes, canyons, and rocky slopes.

Camino del Diablo at Coyote Wash, *Felger 10-168*. 1 mi E of Tinajas Altas, *Van Devender 86-144*.

Stylocline micropoides A. Gray. Desert neststraw

Diminutive, woolly, cool-season annuals; flowers minute and inconspicuous.

Locally common in the Tinajas Altas Mountains on upper bajadas, benches, and washes, and sometimes in soil pockets on rocky slopes and in canyons.

Coyote Water, 18 Mar 1998, *Felger* (observation). Tinajas Altas Canyon, *Felger 98-122*. Vicinity of Tinajas Altas, *Van Devender 05 Mar 1983*.

Trichoptilium incisum (A. Gray) A. Gray. Yellow-head

Annuals with woolly leaves; mostly growing and flowering during cooler seasons, especially in spring, and sometimes flowering into early summer. Flower heads of yellow disk florets.

Widespread in the region, mostly on rocky or gravelly soils; washes, bajadas, and rocky slopes.

Tinajas Altas, *Van Devender 10 Mar 1980*. W end of Tinajas Altas Pass, *Reeves R5425* (ASU).

Trixis californica Kellogg var. **californica.** California threefold

Small shrubs or subshrubs with brittle stems and thin, upright leaves. Flowers yellow and ray-like (bilabiate).

Canyons, bajadas, and rocky slopes including extremely arid hills to higher elevations in the mountains. It has been in the region for more than 11,000 years.

Tinajas Altas, *Vorhies 16 Apr 1924*. Tinajas Altas Pass, 4 mi W of Tinajas Altas, *Webster 24257*. Granitic hills at SW side of Tinajas Altas range, 10 Jan 2002, *Felger* (observation). †Butler Mts, leaf fragments, 740–8160 ybp (3 samples). †Tinajas Altas, leaf fragments, 4010–10,950 ybp (7 samples).

Viguiera parishii, see **Bahiopsis parishii**

Xanthisma spinulosum (Pursh) D.R. Morgan & R.L. Hartm. var. **gooddingii** (A. Nelson) D.R. Morgan & R.L. Hartm. [*Machaeranthera pinnatifida* (Hook.) Shinners var. *gooddingii* (A. Nelson) B.L. Turner & R.L. Hartm. *Haplopappus spinulosus* (Pursh) DC. subsp. *gooddingii* (A. Nelson) H.M. Hall] Spiny goldenweed

Short-lived herbaceous perennials and also flowering in the first season. Ray and disk florets bright yellow, mostly in spring but also with summer rains.

Mostly in canyons and on slopes to the summit, and sometimes along washes and on the desert floor. This or a closely related *Xanthisma* has been in the flora region for more than 11 millennia.

Borrego Canyon, *Felger 92-617*. 1 mi N of Tinajas Altas, *Kurtz 1169*. †*X.* cf. *spinulosum*: Butler Mts, involucres, achenes, 740–11,250 ybp (7 samples). †Tinajas Altas, achenes, 4010 & 9900 ybp.

BORAGINACEAE—Borage Family (includes Hydrophyllaceae)

There are 17 species in this family recorded for the flora area and all are annuals or semi-herbaceous perennials and all except *Tiquilia* grow only during the cooler seasons (see Felger 2000).

1. Dwarf, suffrutescent perennials; stems with a forked branching pattern (pseudo-dichotomous); leaves with 2 or 3 (4) pairs of shallowly impressed veins, the leaf blades 3–8 mm long; flowers essentially sessile and axillary, the corollas lavender **Tiquilia**

1. Winter-spring annuals or sometimes semi-shrubby and the corollas white; stems not forked; leaf veins not impressed, the blades often more than 8 mm long; corollas various colors.

2. Plants stinky with glandular, viscid hairs; inflorescences helicoid (coiled like a scorpion tail); flowers lavender **Phacelia**

2. Herbage not viscid glandular; inflorescences helicoid or not; flowers of various colors.

3. Plants with stiff, glassy or conspicuously harsh hairs; flowers white or yellow-orange; fruits with 1 or 4 nutlets.

4. Flowers yellow-orange; nutlets 4, without a ventral groove **Amsinckia**

4. Flowers white; nutlets 1 or 4, with a ventral groove usually forked near the base, the nutlet attachment forms a triangular slit at the fork **Cryptantha**

3. Herbage softer or relatively so, the hairs not noticeably harsh; flowers white, pinkish, or lavender; fruits with 4 or more seeds.

5. Leaves narrowly linear; corollas white; fruits of 4 nutlets spread open like tiny, open jaws with the marginal teeth **Pectocarya**

5. Leaves narrow or not, but not narrowly linear; corollas pinkish, purplish, or white; fruits not spread open as above, and not toothed, the seeds more than 4 (mostly many).

6. Leaves sessile or the blade tapering into the petiole, the margins entire (sometimes inrolled); flowers pinkish or purplish **Nama**

6. At least the lower leaves petioled, the petiole and blade clearly differentiated, the blades pinnately lobed, toothed, or wavy.

7. Stems slender and delicate; leaves pinnately lobed; flowers pale violet or lavender with a pale yellow throat **Eucrypta**

7. Stems thick, semi-succulent, short and stubby; leaf blades ovate; flowers whitish **Phacelia neglecta**

AMSINCKIA—Fiddleneck

Winter-spring annuals, mostly erect, the herbage with conspicuously coarse hairs. Flowers bright yellow-orange.

1. Calyx lobes 5, about equal in size; back of nutlets rough and arched with a high keel and sharp or ragged-edged ornamentations **A. intermedia**

1. Calyx lobes unequal in size, with 5 or mostly 3 lobes with 1 or 2 lobes 2- or 3-toothed at tip due to fusion of lobes; back of the nutlets smooth, enamel-like with smooth-edged bumps (tessellated), not arched, the keel not raised or only slightly so **A. tessellata**

Amsinckia intermedia Fisch. & C.A. Mey. devil's-lettuce, fiddleneck; cetkom

Cool-season annuals. Plants rough-haired, the calyx lobes 5 and about equal in size, and the nutlets rough with ragged-edged ornamentations. Flowers yellow-orange.

Widespread in the region, from lowest to high elevations. Documented for the region from more than 11,250 years ago.

Camino del Diablo at Coyote Wash, *Felger 10-169.* Tinajas Altas, *Van Devender 5 Mar 1983.* †Butler Mts, nutlet, 11,250 ybp. †Tinajas Altas, nutlet, 9230 ybp.

Amsinckia tessellata A. Gray var. **tessellata.** Desert fiddleneck; cetkom

Cool-season annuals resembling *A. intermedia*, but often more robust, and the calyx lobes 3 or 5 and unequal in size (often 2- or 3-toothed at tip due to fusion of lobes), the nutlets with smooth-edged bumps (tessellated). Flowers yellow-orange.

Sandy soils at least in the southern part of the Lechuguilla Valley. Common across the Cabeza Prieta Refuge. It has been in the region for at least 15,000 years.

Camino del Diablo at W boundary of Cabeza Prieta, *Felger 10-161.* †Butler Mts, nutlets, 10,360 ybp. †Tinajas Altas, nutlets, 9230–15,050 ybp (3 samples).

CRYPTANTHA

Winter-spring annuals and one species of long-lived annuals or short-lived perennials; growing and flowering only during the cooler seasons, the plants beset with harsh, glassy hairs. Flowers small and white. Fruits with 1 or 4 nutlets enclosed in a calyx covered with harsh, glassy hairs, the whole structure resembling a miniature bur. Nutlets all similar or dissimilar either in size and/or ornamentation and how readily they fall out of the calyx. Cryptanthas are among the most diverse and widespread plants in the region.

1. Nutlet margins knife-edged or winged.
   2. Calyx broad (lobes ovate to lance-ovate); nutlet wing usually as wide as the nutlet body and fringed with finger-like projections; annuals ____ **C. pterocarya**
   2. Calyx narrow (lobes lanceolate); nutlet wing narrow and bead-like (much narrower than the body) and entire; annuals to short-lived perennials ____ **C. racemosa**
1. Nutlet margins rounded or angled but not knife-edged or winged.
   3. Inflorescences or their branches obviously curled; flowers without bracts between them.
      4. Plants often about as wide as tall, branching from near base; flowers crowded in inflorescence; 1 of the 4 nutlets larger than the others ____ **C. angustifolia**
      4. Plants often taller than wide; flowers often not crowded in inflorescence; all 4 nutlets of the same size (or perhaps 1–3 per fruit) ____ **C. barbigera**
   3. Inflorescences or their branches not prominently curled; bracts present beneath (subtending) at least some flowers.
      5. Stems not especially slender and wire-like; roots and stems without conspicuous dye; bracts relatively few; nutlets 1 per fruit ____ **C. maritima**
      5. Stems slender and wire-like; roots and stems with copious purple dye; each flower subtended by a leaf-like bract; nutlets 4 per fruit ____ **C. micrantha**

Cryptantha angustifolia (Torr.) Greene. Narrow-leaf cryptantha, desert cryptantha

One of the most widespread and abundant cool-season annuals in the region. Flowers white. This is one of those itchy plants that gets in your socks and sleeping bag, revealing a dispersal mechanism.

Valley bottoms and plains, canyons, and rocky slopes.

Tinajas Altas, *Van Devender 5 Mar 1983.* Tinajas Altas Pass, *Reeves R5405* (ASU).

Cryptantha barbigera (A. Gray) Greene. Bearded cryptantha

Cool-season annuals; flowers white. The plants are sometimes sterile with abnormal growth due to infestations of mites.

Widespread across the flora area; sandy soils of washes and plains, and on rocky slopes to higher elevations. It was in the region more than 5100 years ago

Tinajas Altas Mts, above the tinajas, *Felger 98-137.* †Tinajas Altas, nutlets, 5080 ybp.

Cryptantha maritima (Greene) Greene [*C. maritima* var. *pilosa* I.M. Johnst.] White-haired cryptantha

Cool-season annuals; flowers minute. As with *C. barbigera*, the plants are sometimes deformed by mites and do not produce flowers. The varieties do not seem worthy of recognition; both occur intermixed (Felger 2000).

Common and widespread; washes and sand flats, and bajadas to rocky slopes at higher elevations. It has been in the region for more than 11,000 years.

Tinajas Altas, *Kearney 10905.* Canyon below Raven Butte Tank, *Felger 10-220.* Tinajas Altas Pass, *Reeves R5401* (ASU; annotated by Jeff Brasher, 2001, "mixed collection, var. *maritima* & var. *pilosa*"). †Butler Mts, calyx, nutlets, 740–10,360 ybp (3 samples). †Tinajas Altas, fruits, nutlets, 4010–11,040 ybp (8 samples).

Cryptantha micrantha (Torr.) I.M. Johnst. subsp. **micrantha.** Dwarf cryptantha

Cool-season annuals; plants diminutive with very slender stems, the roots and stems staining red-purple, the flowers minute and white. This is the smallest cryptantha in the region. It is common in immediately adjacent regions and expected within the core flora area in sandy soils of valley bottoms and desert plains.

Cabeza Prieta Refuge: Pinta Sands, *Felger 92-17.*

Cryptantha pterocarya (Torr.) Greene var. **cycloptera** (Greene) J.F. Macbr. Wing-nut cryptantha

Cool-season annuals. Readily recognized by the broad sepals, green when fresh and only moderately hairy, relatively large fruits, and relatively large nutlets with broad, ornamented wings.

Widespread throughout the flora area; desert flats, bajadas, washes, canyons, and rocky slopes to highest elevations, and present in the region more than 11,000 years ago.

Tinajas Altas, *Van Devender 10 Mar 1980.* Canyon below Raven Butte Tank, *Felger 10-219.* †Butler Mts, nutlets, 10,360 ybp. †Tinajas Altas, nutlets, 11,040 ybp.

Cryptantha racemosa (S. Watson ex A. Gray) Greene. Bushy cryptantha

Annuals, highly variable in size, or short-lived perennial herbs or subshrubs; growing and flowering only during cooler seasons; flowers white. This species and *C. holoptera*, known from nearby northwestern Sonora, are the only cryptanthas in the region that survive more than one season.

Rocky slopes and sandy gravelly washes in the Tinajas Altas Mountains to higher elevations. It has been in the region for at least 11,000 years.

Vicinity of Tinajas Altas, 1700 to 1900 ft, on cliffs, *Van Devender 5 Mar 1983.* W end Tinajas Altas Pass, *Reeves R5423* (ASU; originally identified as *C. holoptera* (A. Gray) Macbr., the fruits are not mature). †Butler Mts, calyx, nutlets, 10,360 ybp. †Tinajas Altas, calyces, nutlets, 8970–11,040 ybp (3 samples).

†**Cryptantha utahensis** (A. Gray) Greene. Scented cryptantha

Annuals. This species was at Tinajas Altas 11,000 years ago and is presently in the Mojave Desert and pinyon-juniper regions of Mohave County, Arizona, above about 950 m, and also in east-central California to southwestern Utah.

†Tinajas Altas, calyx, nutlets, 11,040 ybp.

Eucrypta micrantha (Torr.) A. Heller. Desert hideseed

Delicate cool-season annuals, aromatic and viscid-glandular; leaves pinnately divided; flowers small, the corollas pale violet or lavender with a pale yellow throat.

Often in protected niches beneath shrubs or sheltered among rocks. Widespread; washes, bajadas, canyons, and rocky slopes.

Coyote Water, *Felger 05-134.* Tinajas Altas, *Van Devender 5 Mar 1983.* Canyon below Raven Butte Tank, *Felger 10-229.*

NAMA—Purple mat

1. Plants semi-prostrate, matted; longer stem hairs 0.4 mm; corollas bright lavender-pink; seeds dark brown, about as wide as long ____ **N. demissum**

1. Plants erect with ascending branches, with age sometimes spreading-prostrate but not matted; longer stem hairs 0.8–1.2 mm; corollas pale lavender to purple; seeds yellowish, about twice as long as wide ____ **N. hispidum**

Nama demissum A. Gray var. **demissum.** Purple mat

Cool-season annuals, mostly semi-prostrate, low and often matted. Flowers bright lavender-pink.

Mostly along washes and gravelly soils of bajadas and plains; often in open, otherwise barren areas such as desert pavement. The plants are more compact, closer to the ground, generally smaller and with brighter and darker-colored flowers than the more common *N. hispidum*.

1 km SE of mouth of Borrego Canyon, *Felger 98-112.*

Nama hispidum A. Gray var. **spathulatum** (Torrey) C.L. Hitchc. [*N. coulteri* A. Gray] Bristly nama

Cool-season annuals, erect with ascending branches, or with age sometimes spreading-prostrate but not matted. Flowers pale lavender to purple.

Widespread and common across the flora area, especially washes, sandy flats, bajadas, and canyons.

Coyote Water, *Felger 04-52.* Tinajas Altas, *Felger 10-191.* Tinajas Altas Pass, *Reeves 5413* (ASU). Surveyors Canyon, canyon bottom, *Felger 10-214.* Frontera Canyon, 18 Mar 1998, *Felger* (observation).

PECTOCARYA—Comb-bur, comb-seed

Small spring annuals. Leaves narrow, lower ones opposite, appearing as a basal rosette, the stem leaves alternate. Inflorescences not helicoid or only moderately so. Flowers minute, at least sometimes cleistogamous; petals white. Nutlets 4, spreading open like tiny jaws, the margins variously toothed.

1. Nutlets not all alike (heteromorphic)—the pairs dissimilar in size and the margins also dissimilar, and each nutlet within a pair slightly different ______ **P. heterocarpa**
1. Nutlets all alike (or essentially so); the margins and marginal teeth lighter-colored (often yellowish) than the nutlet body ______ **P. platycarpa**

Pectocarya heterocarpa (I.M. Johnst.) I.M. Johnst. Mixed-nut comb-bur

Cool-season annuals; flowers minute, white with a yellow throat.

Widespread; sandy soils of washes and valley floor to the mountains. It was in the Butler Mountains more than 10,000 years ago.

Coyote Water, *Felger 05-137.* Tinajas Altas, *Felger 93-204.* †Butler Mts, nutlets, 10,360 ybp.

Pectocarya platycarpa (Munz & I.M. Johnst.) Munz & I.M. Johnst. Broad-wing comb-bur

Cool-season annuals. Similar to *P. heterocarpa* but the nutlets are noticeably larger with broader and usually yellowish wings.

Widespread including washes, desert flats, and bajadas to rocky slopes. It was at Tinajas Altas more than 10,600 years ago.

Coyote Water, *Felger 05-137A.* Tinajas Altas, *Van Devender 5 Mar 1983.* †Tinajas Altas, nutlets, 10,600 ybp.

PHACELIA—Scorpion-weed

The phacelias in the flora area are cool-season annuals, glandular pubescent and can cause unpleasant dermatitis. Inflorescence branches are generally helicoid (curled at the tip like a scorpion tail) except in *P. neglecta*, and the flowers lavender, lavender blue, or white.

1. Plants not especially stinky; stems thick, stubby, and semi-succulent; leaf blades about as wide as long, more or less ovate; inflorescences generally not taller than the leaves; seeds many per capsule, solid, more or less terete in cross--section, similar on all sides ______ **P. neglecta**
1. Plants noticeably stinky; stems not noticeably thick and succulent, or at least not short and stubby; leaf blades more than twice as long as wide, pinnate to pinnatifid; inflorescences taller than the leaves; seeds 4 per capsule, boat-shaped, one side excavated (with a cavity) on either side of a septum (a ridge down the middle), the other side convex.
   2. Fruiting pedicels mostly 1.0–1.5 mm long, shorter than the capsules; fruiting sepals 3–5 mm long, about as long as to ¼ longer than capsules ______ **P. crenulata**
   2. Fruiting pedicels 4–7 mm long, longer than the capsules; fruiting sepals 5–6.5 mm long, about twice as long as the capsules ______ **P. pedicellata**

Phacelia crenulata Torr. ex S. Watson var. **ambigua** (M.E. Jones) J.F. Macbr. [*P. ambigua* M.E. Jones. *P. minutiflora* J.W. Voss ex Munz] Desert heliotrope, desert scorpion-weed

Cool-season annuals, mostly erect, stinky, glandular pubescent, and can cause unpleasant dermatitis. Inflorescence branches curved (helicoid or 'scorpioid'). Flowers lavender-purple. Seeds 4 per capsule.

This is the most abundant and widespread phacelia in the region; in many habitats including washes, canyons, bajadas, plains, and rocky slopes to their summits.

Coyote Water, *Felger 05-128.* Tinajas Altas, *Van Devender 5 Mar 1983.*

Phacelia neglecta M.E. Jones. Alkali phacelia

Short, stubby cool-season annuals, often less than 8 cm tall, semi-succulent with the main stem and root notably thick. Flowers white. Seeds many per capsule. Unlike most phacelias, the plants are not stinky and the inflorescences are short and not coiled (helicoid).

Generally occurring as small, highly localized populations on barren or nearly barren areas of desert pavement and pediments near mountain bases; not common in the flora area.

E margin of Davis Plain, W branch of Camino del Diablo, decomposed granite pediment directly downslope from rocky hill, *Felger 05-62.*

Phacelia pedicellata A. Gray. Pedicellate scorpion-weed

Robust plants, conspicuously glandular-pubescent with an offensive odor, the herbage often pale green. Flowering branches helicoid. Flowers pale lavender-blue. Seeds 4 per capsule.

Canyons bottoms and among rocks, especially on north- and east-facing mountain slopes, from base to higher elevations.

Tinajas Altas, canyon bottom E of tinajas, *Felger 98-145.* Tinajas Altas Canyon, *Felger 98-127.*

†**Phacelia** sp.

This is this only fossil record for a hydrophyll (Hydrophyllaceae, sensu stricto) in the flora area. The seeds are excavated on one side like those of many other phacelias with four seeds per capsule.

†Tinajas Altas, seeds, 1230 ybp.

Tiquilia palmeri (A. Gray) A.T. Richardson. PALMER'S CRINKLEMAT

Low-growing perennials forming small semi-prostrate mats, the areal portions drying back during drought and resprouting from very slender roots issuing from deep, very thick, long, black roots. Stems with a forked branching pattern (pseudo-dichotomous). Leaves with 2 or 3 (4) pairs of shallowly impressed veins; the blades 3–8 mm long. Growing and flowering non-seasonally following spring and summer-fall rains; flowers essentially sessile and axillary, the corollas lavender-pink.

Sand flats and dunes near the Butler Mountains and expected near the Tinajas Altas Mountains and in the Lechuguilla Valley.

Butler Mts, *Van Devender 27 Mar 1983.*

BRASSICACEAE—MUSTARD FAMILY

The nine species in the flora area are cool-season annuals except *Lyrocarpa*.

1. Fruits of 2 disk-shaped halves (spectacle-shaped) joined along less than 25% of their margins; flowers white and fragrant.
 2. Leaves with slender lobes; petals (fresh) 5–7 mm long; fruiting pedicels 7–20 mm long **Dimorphocarpa**
 2. Leaves with broad, coarse teeth or lobes; petals (fresh) 10–12 mm long; fruiting pedicels 1.5–2.5 mm long **Dithyrea**
1. Fruits not of disk-shaped halves; flowers various colors, fragrant or not
 3. Perennials (sometimes flowering in the first season); petals twisted, 12–20+ mm long; fruits usually widest well above the middle, 8–14 mm wide **Lyrocarpa**
 3. Winter-spring annuals; petals not twisted, not more than 10 mm long; fruits widest at about the middle, less than 7.5 mm wide.
  4. Fruits less than twice as long as wide.
   5. Plants glabrous or with simple hairs; flowers inconspicuous, greenish or whitish; fruits compressed (flattened), 1- or 2-seeded **Lepidium**
   5. Plants (including fruits) with stellate hairs; flowers bright yellow; fruits globose, not at all compressed, several-seeded **Physaria**
  4. Fruits at least 3 times longer than wide.
   6. Fruits turned downward; fruiting pedicels 0.5–1.0 mm long; fruits terete and slender, 2.5–6.5 cm long; stems leafy, the leaves pinnatifid and more or less lanceolate **Caulanthus**
   6. Fruits spreading or erect (not turned downward); fruiting pedicels 4 mm or more in length or if less than 3 mm then leaves all basal and broadly obovate and merely toothed (*Draba*).
    7. Herbage glabrous or with simple hairs; fruits 18–70 mm long **Brassica**
    7. Herbage with forked, branched (dendritic), or stellate hairs; fruits 3.5–12 mm long.
     8. Herbage with branched, candelabra-shaped hairs (stalked and branched above); leaves finely divided, the stem leaves well developed; fruits nearly terete **Descurainia**
     8. Herbage with forked and stellate hairs; leaves merely toothed (not divided), all basal; fruits laterally flattened **Draba**

***Brassica tournefortii** Gouan. SAHARA MUSTARD; *MOSTAZA DEL SAHARA*

Cool-season annuals, extremely variable in size, less than 10 cm tall with leaves 1 cm long to sometimes near 1 m tall with leaves to 80 cm long. When dry and dead the larger plants may break off at the root and become tumbleweeds. Flowers pale yellow and apparently selfing (autogamous).

Widespread and seasonally common in lowland disturbed and natural sites across the flora area, especially on sandy soils; washes and valley plains, and sometimes extending onto rocky slopes and in canyons even at higher elevations.

Sahara mustard is the most seriously invasive species in the flora region. The broad, spreading basal-rosette leaves can effectively prevent establishment of other cool-season annuals. Densely crowded or drought-stressed plants may be less than 15 cm tall with leaves as small as 8 cm and be reproductive, whereas plants on sandy soils with sufficient soil moisture may grow to more than 1 meter across and nearly 1 m tall, making this species the largest herbaceous rosette plant in the region (see Felger 2000).

On March 28, 2010, Richard Laugharn and Felger poked around in the miniature mesquite thicket in the Lechuguilla Valley where the Camino del Diablo crosses Coyote Wash and Felger made the following observations: Much of the ground is now 100% covered by *Brassica tournefortii* of incredible size variation, but each local niche or micro-habitat of *Brassica* generally has same-sized plants—some very crowded stands consist of dwarfed plants, some reproducing with only a single fruit with 3–7 seeds, the larger leaves 1.0 or 1.4 to several cm long, and basal rosette leaves often only 1–3 or sometimes not developing, the stems extremely slender, unbranched and the plants 8.7– 11.4 cm and more in height. Other, less crowded, robust plants have rosette leaves more than 30 cm long. Obviously *B. tournefortii* is changing the cool-season species composition in this habitat.

Native to the Old World, *B. tournefortii* has spread explosively across the Sonoran Desert, especially in sandy-soil habitats. The extreme plasticity in size and presumed selfing are likely components in its success as an invasive species. It was first reported from southeastern California by Jepson (1923–1925) and established in agricultural areas in southeastern California by 1938, recorded from Yuma in 1957, northwestern Sonora in 1966, and widespread across the Sonoran Desert region since at least the 1970s (Dimmitt & Van Devender 2009; Felger 2000; Malusa et al. 2003; Van Devender et al. 1997).

Coyote Water, *Felger 04-33.* Camino del Diablo at Coyote Wash, 28 Mar 2010, *Felger 10-172.* Surveyors Canyon, Lamb Tank, *Felger 10-197.* Canyon below Raven Butte Tank, *Felger 10-242.* Camino del Diablo, E of Raven Butte, 29 Nov 2001, *Felger* (observation). Tinajas Altas Mts, above the tinajas, 19 Mar 1998, *Felger* (observation).

Caulanthus lasiophyllus (Hook. & Arn.) Payson [*Guillenia lasiophylla* (Hook. & Arn.) Greene. *Thelypodium lasiophyllus* (Hook. & Arn.) Greene] CALIFORNIA MUSTARD

Spring annuals; flowers minute, white or pink-purple. Fruits slender, straight or nearly so, terete, and turning downward as they mature.

Widespread; washes, valley plains, and mountains. Often in shaded niches beneath spinescent shrubs.

Coyote Water, *Felger 05-131.* Tinajas Altas Pass, *Reeves 5404* (ASU). Tinajas Altas, *Felger 10-181.* Tinajas Altas Mts, above the tinajas, 19 Mar 1998, *Felger* (observation).

Descurainia pinnata (Walter) Britton subsp. **ochroleuca** (Wooton) Detling. WESTERN TANSY-MUSTARD; *PAMITA; SU'UVAD*

Spring annuals; leaves highly dissected, the flowers minute, pale yellow.

Widespread across the flora area, sandy to rocky soils, washes, plains, bajadas, hills, and mountains. Often in shaded niches, mostly beneath spinescent shrubs. This tansy mustard was an important medicinal plant. It was present in the region more than 10,000 years ago.

Vicinity of Tinajas Altas, *Van Devender 05 Mar 1983.* Coyote Water, *Felger 05-152.* Frontera Canyon, 18 Mar 1998, *Felger* (observation). †Butler Mts, fruit, 10,360 ybp.

Dimorphocarpa pinnatifida Rollins. DUNE SPECTACLE-POD

Spring annuals, often becoming large and sprawling. Flowers white and fragrant; fruits of two disc-shaped segments, each 1-seeded.

A single, large and many-stemmed plant was encountered in the Tinajas Altas Mountains. It was probably a waif and apparently not reproducing, presumably due to lack of cross-pollination since they are outcrossers (Andrew Salywon, personal communication 2007). Endemic to dunes in nearby northwestern Sonora and southwestern Arizona.

Tinajas Altas, canyon bottom above uppermost tinaja, one large plant seen, no fruit setting, *Felger 98-138.*

Dithyrea californica Harv. CALIFORNIA SPECTACLE-POD

Spring annuals. Flowers cream white and fragrant.

Characteristically on sandy soils. Recorded east of the Butler Mountains and in the Pinta Sands in Cabeza Prieta Refuge.

Butler Mts, *Van Devender 27 Mar 1983.*

Draba cuneifolia Nutt. ex Torr. & A. Gray [*D. cuneifolia* var. *integrifolia* S. Watson. *D. cuneifolia* var. *sonorae* (Greene) Parish] WEDGE-LEAF DRABA

Small winter-spring annuals; leaves broad and in a basal rosette. Flowers small and white.

Seasonally common; washes, desert plains, sand flats, canyons, and rocky slopes especially in sheltered niches. This species or a similar one was at Tinajas Altas 11,000 years ago.

Camino del Diablo, SSE of Raven Butte, *Felger 05-36.* Tinajas Altas, 1200 ft, on slopes and in washes, *Reeves R5382* (ASU). Frontera Canyon, 18 Mar 1998, *Felger* (observation). †*D.* cf. *cuneifolia*, Tinajas Altas, fruits, 10,950 ybp.

Lepidium lasiocarpum Nutt. subsp. **lasiocarpum.** SAND PEPPER-WEED; *LENTEJILLA*

Cool-season annuals. Flowers small and inconspicuous; fruits disc-shaped and notched at apex.

Common and widespread; washes and flats, canyons, and less common on rocky slopes. It has benn in the region for at least 10,400 years.

Coyote Water, *Felger 05-130.* Tinajas Altas, wash floor above tanks, *Van Devender 10 Mar 1980.* Canyon below Raven Butte Tank, *Felger 10-233.* †Butler Mts, fruits with flattened pedicels, seeds, 8160 & 10,360 ybp.

†**Lepidium** sp./spp. Pepper-weed

Pepper-weed has been in the flora area for more than 18,700 years.

†Tinajas Altas, fruits, seeds, 8700–18,700 ybp (5 samples). Butler Mts, fruits, 11,250 ybp.

Lyrocarpa coulteri Hook. & Harv. Lyre-pod; ban censañig

Weak-stemmed and sprawling herbaceous perennials, sometimes to 1+ m tall, and sometimes flowering in the first season; plants with stellate hairs. Flowers especially fragrant at night, yellow to purple-brown, the petals slender and often twisted, often 1.5–2+ cm long. Growing and flowering any time of year with sufficient soil moisture.

Widespread in the mountains, often growing in the protection of large rocks and beneath shrubs and trees. Washes, canyons, gravelly bajadas, and rocky slopes to higher elevations. This is the only perennial member of the mustard family in the flora area.

Tinajas Altas, 29 Mar 1930, *Harrison 6563.*

Physaria tenella (A. Nelson) O'Kane & Al-Shehbaz [*Lesquerella tenella* A. Nelson] Desert bladderpod

Cool-season annuals; flowers bright yellow; fruits globose, hollow and bladder-like.

Widespread, especially at lower elevations; washes, sand flats, valley plains, and mountains, often growing in the protection of small shrubs.

Coyote Water, *Felger 04-58.* Tinajas Altas, *Van Devender 5 Mar 1983.* Tinajas Altas Canyon, 19 Mar 1998, *Felger* (observation).

†**Thysanocarpus curvipes** Hook. Lacepod

Cool-season annuals. Lacepod was well established in the flora region from at least 9000 to 15,000 years ago. The nearest present-day population is in the Agua Dulce Mountains on the east side of Cabeza Prieta Refuge.

†Butler Mts, 10,360 ybp. *Thysanocarpus* cf. *curvipes*, Tinajas Altas, 8970–15,050 ybp (8 samples).

BURSERACEAE—Torchwood Family

Bursera microphylla A. Gray. Elephant tree; *torote*; 'usabkam.

Large shrubs or small trees, with thick, semi-succulent limbs, and pungently aromatic drought-deciduous leaves. Flowers minute, cream-color, produced with the emerging leaves in the first summer rains.

Rocky slopes to peak elevations and sometimes on upper bajadas. The plants often show signs of repeated freeze damage. A large elephant tree in Frontera Canyon measured 4 m tall and 6 m across, with a trunk 110 cm tall and 130 cm in circumference. This species was at Tinajas Altas 6000 years ago, indicating a nearly frost-free habitat.

Tinajas Altas, *Vorhies 16 Apr 1924.* Tinajas Altas Mts, *Van Devender 86-12.* †Tinajas Altas, seeds, 5940 ybp.

CACTACEAE—Cactus Family

Some of the 13 cactus species in the present–day flora are defining aspects of the landscape, while others can be seen only by diligent searching. Two species, the many-headed barrel cactus (*Echinocactus polycephalus*) and beavertail cactus (*Opuntia basilaris*), do not range eastward from the arid, general region of the flora area.

1. Columnar cacti, becoming at least 2 m tall, the stems not constricted into joints or pads ______ **Carnegiea**
1. Not columnar cacti, less than 2 m tall.
  2. Large barrel cacti, usually unbranched (rarely 1- or 2-branched from base); stem more than 20 cm in diameter; larger spines stout and glabrous or with very minute non-overlapping hairs; flowers and fruits glabrous______ **Ferocactus**
  2. Growth forms various, not large unbranched barrel cacti; individual stems less than 15 cm in diameter; spines generally not very thick and rigid (except in *Echinocactus* and *Grusonia*).
    3. Plants forming dense mounds of multiple stems ("heads") each 9–12 cm thick; spines very stout and rigid, tomentose with overlapping white hairs (use magnification); exterior of flowers and fruits copiously white-woolly ______ **Echinocactus**
    3. Plants not forming dense mounds, the stems mostly less than 7 cm thick and the spines not exceptionally stout and rigid, or plants with jointed stems; spine surfaces not covered with short hairs; flowers and fruits glabrous, scaly, or bearing spine clusters but not woolly.
      4. Chollas or prickly-pears; stems constricted into joints or pads; areoles with glochids (small spines deciduous at a touch).

5. Prickly-pear; stem segments (cladodes) compressed as short, thick pads, not tuberculate, with glochids but lacking larger spines ____ **Opuntia**

5. Chollas; stem segments ("joints") more or less rounded in cross-section (cylindroid), often tuberculate, with glochids and spines.

6. Plants often taller than wide; stems often with more than 6 joints; spines round in cross-section, the largest spines not pointing downward; spine sheaths covering most of each spine; fruits spineless or spiny ____ **Cylindropuntia**

6. Plants usually forming colonies much wider than tall; stems with 1–6 joints; larger spines flattened, sharp-edged and pointing downward; spine sheaths tiny, only at spine tips and soon deciduous; fruits densely spiny ____ **Grusonia**

4. Not chollas or prickly-pears; stems not constricted into joints or pads, without glochids.

7. Stems less than 2 cm diameter, more than 10 times longer than wide; spines rather inconspicuous, 1–8 mm long, not hooked; rare ____ **Peniocereus**

7. Stems 3–9 cm wide (if less than 3 cm then the central spines hooked), less than 5 times as long as wide; spines conspicuous, more than 8 mm long.

8. Most areoles with at least one hooked spine; flowers about 1 cm wide; fruits spineless even when young ____ **Mammillaria**

8. Spines straight or curved but not hooked; flowers more than 4 cm wide; fruits spiny at least when young ____ **Echinocereus**

Carnegiea gigantea (Engelm.) Britton & Rose [*Cereus giganteus* Engelm.] SAGUARO, SAHUARO; HA:SAÑ

This giant columnar cactus is the very symbol of the Sonoran Desert in Arizona and Sonora. The large white flowers open at night and usually remain open much of the following day; flowering late April through much of May. The fruits, with their sweet, juicy red pulp, ripen in June.

Common on upper bajadas and rocky slopes throughout the mountains. Saguaros have grown in the flora area for at least nine millennia—dates more than nine millennia may be due to contaminates.

Saguaro fruits are delicious, the fruits and seeds were major food resources, and the fruit pulp was made into wine. Saguaros are relatively uncommon near the tinajas, undoubtedly due to the desert bighorn that smash the stems with their horns in order to get to the succulent tissue (e.g., Russo 1956; Fig. 14).

†Tinajas Altas, seeds, 1230–8970 ybp (6 samples). †Butler Mts, seeds, 3820–11,250 ybp (4 samples; the oldest dates may be contaminants).

CYLINDROPUNTIA—CHOLLA; *CHOLLA*

Chollas are a conspicuous feature of the landscape and the most diverse cactus genus in the region.

1. Main axis or trunk well developed, straight and erect, often with persistent dead joints bearing blackened spines; joints (3) 4–6+ cm in diameter (excluding spines); tepals pale yellow-green ____ **C. bigelovii**

1. Main axis or trunk not well developed, or if so, then not straight and erect, and without persistent dead joints; joints 3 cm or less in diameter.

2. Joints mostly 1 cm or less in diameter, their surfaces readily visible through the spines, the lower areoles of each joint likely to bear only glochids; stems remaining green all year; tubercles "flat" and sharply defined with rhomboid (diamond-shaped) outlines; each areole in a groove ____ **C. ramosissima**

2. Joints 1.5 cm or more in diameter, their surfaces partially to fully obscured by spines, usually evenly spiny from tip to base of each joint.

3. Stem tubercles mostly 16–24 mm long; inner (larger) tepals orange-brown to dull golden-yellow, filaments red; basal tubercles of fruits much longer than the upper tubercles ____ **C. acanthocarpa**

3. Stem tubercles 11–16 mm long; inner tepals silvery white, the filaments green or yellowish; basal tubercles of fruits nearly equal to the upper ones ____ **C. echinocarpa**

Cylindropuntia acanthocarpa (Engelm. & J.M. Bigelow) F.M. Knuth var. **coloradensis** (L.D. Benson) Pinkava [*Opuntia acanthocarpa* Engelm. & J.M. Bigelow var. *coloradensis* L.D. Benson] BUCKHORN CHOLLA; *CHOYA*; CIOLIM (also called HANAMĪ, the general term for cholla)

Shrub-sized plants; flowers yellow-orange to dull golden yellow, March and April. Fruits become dry upon ripening in May.

Common and widespread on upper bajadas, canyons, and rocky slopes to higher elevations. The flower buds were prepared as a vegetable. This species has grown in the region for more than 10,000 years.

E end of Tinajas Altas Pass, *Reeves R5395* (ASU). Mesa just E of Tinajas Altas, *Felger 08-190*. SW side of Tinajas Altas range, flats adjacent to granitic hills, 10 Jan 2002, *Felger* (observation). †Tinajas Altas, seeds (actually the aril-covered seeds), 1230–10,070 ybp (6 samples; variety unknown).

Cylindropuntia bigelovii (Engelm.) F.M. Knuth [*Opuntia bigelovii* Engelm.] TEDDYBEAR CHOLLA; *CHOYA GÜERA*; HADSADKAM (also called HANAMĪ, the general term for cholla). **Fig. 3.**

Often 0.5–1.5 m tall, the trunk erect, stout, straight, and usually beset with dead, persistent branches (joints). Flowers pale yellow-green; March and April. Fruits moderately fleshy, leathery, and yellow.

Abundant on desert pavements, sandy plains and flats, bajadas, pediments, and rocky slopes. It is a clonal species; the upper or younger joints fall at a touch, the spines are painful to pull out of your flesh, and the plants propagate prolifically from readily rooting fallen joints. Packrats have been collecting teddybear cholla for more than 15.7 millennia.

Tinajas Altas, *Mearns 348* (US). 0.5 km N of Tinajas Altas, *Reeves 5393* (ASU). Flats at SW side of Tinajas Altas range, 10 Jan 2002, *Felger* (observation). †Tinajas Altas, seeds (actually the aril-covered seeds), 1230–15,680 ybp (10 samples). †Butler Mts, spines, seeds, 11,060 ybp.

Cylindropuntia echinocarpa (Engelm. & J.M. Bigelow) F.M. Knuth [*Opuntia echinocarpa* Engelm. & J.M. Bigelow. *O. wigginsii* L.D. Benson] SILVER CHOLLA

Small chollas (the plants generally smaller than those of *C. acanthocarpa*). Flowers silvery white with green filaments; March and April. Fruits dry upon ripening in late May and early June.

Upper bajadas at base of the mountains, onto sandy flats, and generally downslope of the somewhat simillar *C. acanthocarpa*.

SE side of Tinajas Altas Mts, 3 Feb 1990, *Felger* (observation).

Cylindropuntia ramosissima (Engelm.) F.M. Knuth [*Opuntia ramosissima* Engelm.] DIAMOND CHOLLA

Slender-stem chollas to 1 (1.2) m tall but usually much shorter, sometimes forming spreading colonies; the common name derives from the diamond-like pattern formed by the low-relief tubercles. Flowers small, pale yellowish to greenish brown or cream-color with reddish purple outer tepals; opening mid- to late-afternoon, April and May. Fruits dry at maturity.

Especially common on bajadas along the western side of the Lechuguilla Valley in the Goldwater Range and the Tinajas Altas region. This xerophytic cholla is documented from the Butler Mountains more than 10,400 years ago.

E end of Tinajas Altas Pass, *Reeves 5394* (ASU). Camino del Diablo SE of Raven Butte, *Felger 04-08*. SW side of Tinajas Altas range, flats adjacent to granitic hills, 10 Jan 2002, *Felger* (observation). †Butler Mts, stem, 10,360 ybp.

Echinocactus polycephalus Engelm. & J.M. Bigelow var. **polycephalus.** MANY-HEADED BARREL CACTUS, COTTON-TOP CACTUS, CANNONBALL CACTUS; *BIZNAGA*

Multiple-headed, mound-forming barrel cacti with a dense cover of stout spines; young areoles densely white woolly. The spine surfaces are red but covered by felt-like, overlapping, short, white hairs imparting a dull pink-gray color. This covering suddenly becomes translucent when wet, revealing the blood-red spine surfaces—the spines turn red in the rain but soon dry and revert to their usual dull color. Flowers yellow and confined (protected?) by the dense spine cover; flowering late May and June. Fruits densely woolly, drying soon after maturity, tenaciously held among the closely set spines and may remain in place for one year or more, the seeds falling as the fruits disintegrate. Scattered, mostly on upper bajadas and sandy valley flats.

People in Yuma call it the "cannonball cactus" by because of "the small rounded stems piled up." A giant mound-shaped plant on a sandy plain near the eastern boundary of the flora area measured 190 × 201 cm wide, 81 cm tall, and had more than 152 stems ("heads"). We have not seen seedlings or small juvenile plants, and recruitment presumably is a rare event.

This cactus has been in the Tinajas Altas region for more than 43,000 years. Evidence from the fossils indicates it was more common on rocky slopes than today, which is more like the habitat of the northern, or Grand Canyon population, var. *xeranthemoides* J.M. Coult., than that of var. *polycephalus*. In fact, the fossils may be more like the northern variety than the southern one.

0.5 km E of Camino del Diablo on road to Borrego Canyon, *Felger 90-20.* †Butler Mts, seeds, 3820–11,060 ybp (5 samples). †Tinajas Altas, spines, seeds, 9700–15,680 (4 samples), & >43,000 ybp.

Echinocereus engelmannii (Parry ex Engelm.) Lem. var. **chrysocentrus** (Engelm. & J.M. Bigelow) Rümpler. STRAWBERRY HEDGEHOG CACTUS; *PITAYITA*; 'ISVIGĬ

Stems several to many, branching mostly from near the base. Flowers very showy, 7.5–9 cm long, bright purple-magenta; flowering March and early April. Fruits sweet and edible, ripe late May and early June. Upon ripening, the fruit pulp and seeds are quickly consumed by a variety of animals, especially birds that poke a hole in the side of the fruit. Ants quickly finish off what the birds leave and hollowed-out fruits are common.

Widespread in the Tinajas Altas Mountains, upper bajadas and rocky slopes.

Tinajas Altas, *Blackwell SF-709.* Bajada at SW side of Tinajas Altas Mts, 10 Jan 2002, *Felger* (observation). Ridge above Tinajas Altas Canyon, 19 Mar 1998, *Felger* (observation).

†**Echinocereus** sp./spp. (probably *E. engelmannii* and/or other species)

Hedgehog cacti have grown in the Tinajas Altas Mountains for more than 43,000 years. Three species and two varieties of present-day *Echinocereus* are known from Organ Pipe Cactus National Monument and Cabeza Prieta National Wildlife Refuge (Felger et al. 2007b; 2012).

†Tinajas Altas, seeds, 1030–10,600 (5 samples), & >43,000 ybp.

Ferocactus cylindraceus (Engelm.) Orcutt [*F. acanthodes* (Lem.) Britton & Rose. *F. acanthodes* var. *eastwoodiae* L.D. Benson] Mountain barrel cactus

Stem nearly always solitary, reaching 0.5–1+ m tall, straight (erect), becoming considerably taller than wide. Spines reddish pink; flowers yellow-green.

Widely scattered on upper bajadas and steep rocky slopes and cliffs. Barrel cacti are fairly scarce in the vicinity of the waterholes such as at Tinajas Altas and Surveyors Tank and on up to the peaks. Most of the larger ones grow on inaccessible cliffs and rock faces. Their scarcity near the tinajas is probably due to bighorn sheep, which dislodge the plants with their horns and eat the fleshy stem (Warrick & Krausman 1989).

This barrel cactus was at least reasonably common from about 11,000–3800 years ago, but its absence in younger middens indicates a decline in abundance and it is still locally not common. Is this change due to climate change or perhaps bighorn sheep, which knock over the plants and eagerly eat them? Across much of its geographic range this species characteristically occurs on rock slopes (e.g., Felger 2000).

Borrego Canyon, *Felger 90-5*. Lower slopes adjacent to Tinajas Altas, *Felger 08-182*. Near Camino del Diablo on road to Coyote Water, 24 Oct 2004, *Felger* (observation). †Butler Mts, spines, seeds, 3820–11,250 ybp (5 samples). †Tinajas Altas, seeds, 4010–10,070 ybp (10 samples).

Grusonia kunzei (Rose) Pinkava [*Opuntia kunzei* Rose. *O. stanlyi* Engelm. ex B.D. Jackson var. *kunzei* (Rose) L.D. Benson. *Corynopuntia kunzei* (Rose) M.P. Griff.] Desert club-cholla, devil cholla

Thick-stemmed club chollas, commonly forming sprawling colonies, and well armed with rather large and very sharp spines. Flowers pale yellow or cream-color; May and June, the fruits ripening late August through the following May.

Scattered on the mid-bajada and upper bajada of the Lechuguilla Valley.

Tinajas Altas, *Harbison 9 Mar 1937* (2 specimens, SD 16999 & 17000). Camino del Diablo, E of Raven Butte, 29 Nov 2001, *Felger* (observation).

MAMMILLARIA

1. Seeds 1.6–2.4 mm long, the lower ⅓ covered with a light-colored, corky cup-like base, the seed surfaces reticulate and wrinkled but not pitted (Note: dried fruits can often be found below the spine clusters in the tubercle axils) ______ **M. tetrancistra**
1. Seeds slightly less than 1 mm long, without a corky base, the seed surfaces pitted ______ **M. grahamii**

Mammillaria grahamii Engelm. [Among the many synonyms are: *M. grahamii* var. *oliviae* (Orcutt) L.D. Benson. *M. microcarpa* Engelm. *M. milleri* (Britton & Rose) Bödeker] Arizona fishhook cactus; *cabeza de viejo*; ban 'isvig, ban cekida

Small globose to cylindroid cacti with hooked spines. Flowers pink and rather showy, produced sporadically in pulses, generally following rainfall from April to September. Fruits red and fleshy, smooth, spineless, pleasantly edible; seeds small and black.

Widely scattered across the region; sandy and rocky soils; upper bajadas and rocky slopes at all elevations. A fishhook cactus, probably this species, has been at Tinajas Altas for more than 18,700 years.

Tinajas Altas, *Reeves 5391* (ASU). Granitic mountain at NW side of Raven Butte, *Felger 05-384*. SE side of Tinajas Altas Mts, 3 Feb 1990, *Felger* (observation). †*M.* cf. *grahamii*, Tinajas Altas, spines, seeds, 1230–18,700 ybp (11 samples).

Mammillaria tetrancistra Engelm. Cork-seed fishhook cactus; *cabeza de viejo*

Small globose to cylindroid cacti with hooked spines. Flowers pink, spring and summer; fruits red, fleshy, and spineless. Basal one third of each seed seated in a corky cup. Although the fleshy part of the fruit is edible, the corky seed-cup will make you spit it out—an easy way to identify this species. No other Sonoran Desert cactus has a corky seed-cup.

Rocky soils, hills and mountains, and sandy soils of upper bajadas. This is the most arid-inhabiting of all mammillarias.

Granite hill, SW side of Tinajas Altas Mts, *Felger 02-6*. Camino del Diablo SSE of Raven Butte, 20 Feb 2005, *Felger* (observation).

†**Mammillaria** sp./spp.

†Butler Mts, hooked spines, 740 & 3820 ybp (probably one or both of the present-day species).

Opuntia basilaris Engelm. & J.M. Bigelow var. **basilaris.** BEAVERTAIL CACTUS. **Fig. 18A, B.**

Dwarf prickly-pears with a very thick caudex and very thick, mostly upright and short pads. Areoles bear glochids but no spines. Flowers showy, rose-pink, the stamens with yellow filaments and yellow anthers; flowering early April; fruits ripe in late May.

Southwestern margin of Cabeza Prieta Refuge and the Tinajas Altas Mountains nearly to the summit although generally scarce on the higher slopes. Mostly on nearly barren desert pavements near the base of the mountain and arid, rocky lower slopes. It is especially common in parts of the Tinajas Altas Pass. Beavertail cactus has grown in the Tinajas Altas Mountains for more than 43,000 years.

In drought the pads shrivel and curl inward, and some or even most of the pads drop off in severe drought almost like deciduous leaves. Many pads have a dead, dried area below the old flowers or fruits—the pad tips seem to desiccate. In cultivation, such as in Tucson, these "dwarf" plants can become substantially larger than those in the wild.

Observations: Borrego Canyon, 3 Feb 1990, *Felger*; Tinajas Altas, 29 Nov 2001, *Felger*. †Tinajas Altas, seeds (actually the aril-covered seeds), 1230–11,040 (8 samples), & >43,000 ybp.

†**Opuntia chlorotica** Engelm. & J.M. Bigelow. PANCAKE PRICKLY-PEAR; *NOPAL RASTRERO*

Shrub-sized prickly-pears. The nearest present-day populations are in mountains in the eastern and central parts of the Cabeza Prieta Refuge and it is more common in the higher mountains of Organ Pipe Monument. This species generally occurs at the upper elevations of the desert and into oak-grassland. It grew at Tinajas Altas more than 11,000 years ago and has been in the Ajo Mountains for at least 32,000 years. Unlike most other cacti in the region, this species seems to have expanded its range during the wetter rainfall climates of the Wisconsin glacial environments, a time of greater winter rainfall and drastically reduced summer rains.

†Tinajas Altas, seed (actually the aril-covered seed), 11,040 ybp.

Peniocereus greggii (Engelm.) Britton & Rose var. **transmontanus** (Engelm.) Backeb. [*Cereus greggii* Engelm. var. *transmontanus* Engelm.] DESERT NIGHT-BLOOMING CEREUS; *REINA DE LA NOCHE, SARRAMATRACA*; HO'OK WA'O

Stems slender, to ca. 1.5 m tall, 4-angled, grayish to grayish purple, mostly few-branched, from a single large tuberous root. Flowers large and white with a long tube; spectacularly fragrant, opening shortly after sunset and wilting quickly after sunrise. Fruits bright red throughout, the pulp juicy and sweet. Flowering occurs synchronously on one or a few nights between late May and July, the fruits generally ripening August and September and occasionally persisting until March.

Widely scattered across the Tinajas Altas Mountains, from the base to higher elevations often growing in the shelter of a nurse shrub. The plants are seldom encountered due to the cryptic nature of the stems and throughout its range it characteristically grows at low densities.

The fruits are edible as a fresh snack food. The roots have been utilized medicinally. Packrats are known to chew the stems like a popsicle. An old, forlorn plant at the Borrego Springs Tank was repeatedly eaten back to a stump by bighorn sheep (Broyles et al. 2007: 597).

Tinajas Altas: *Harbison 6 Mar 1937* (SD 16828); *Mearns 2811* (DS, US). E end Tinajas Altas Pass, *Reeves 5396* (ASU).

CAMPANULACEAE—BELLFLOWER FAMILY

Nemacladus orientalis (McVaugh) Morin [*N. glanduliferus* Jeps. var. *orientalis* McVaugh] REDTIP THREAD PLANT

Small, cool-season annuals with wiry stems. Flowers small, the corollas white with red-tipped lobes.

Known from two localities in the flora area, although probably more widespread.

Coyote Water, *Felger 05-147*. Canyon below Raven Butte Tank, *Felger 10-235*.

CARYOPHYLLACEAE—PINK FAMILY

The two species in the flora area are small, spring annuals.

1. Plants glabrous; stipules conspicuous, papery and white ________ **Achyronychia**
1. Plants densely and conspicuously glandular pubescent; stipules not papery and white ________ **Loeflingia**

Achyronychia cooperi A. Gray & A. Gray. SAND-MAT, FROST-MAT

Cool-season annuals, small and prostrate growing with conspicuous white stipules. Flowers minute and white.

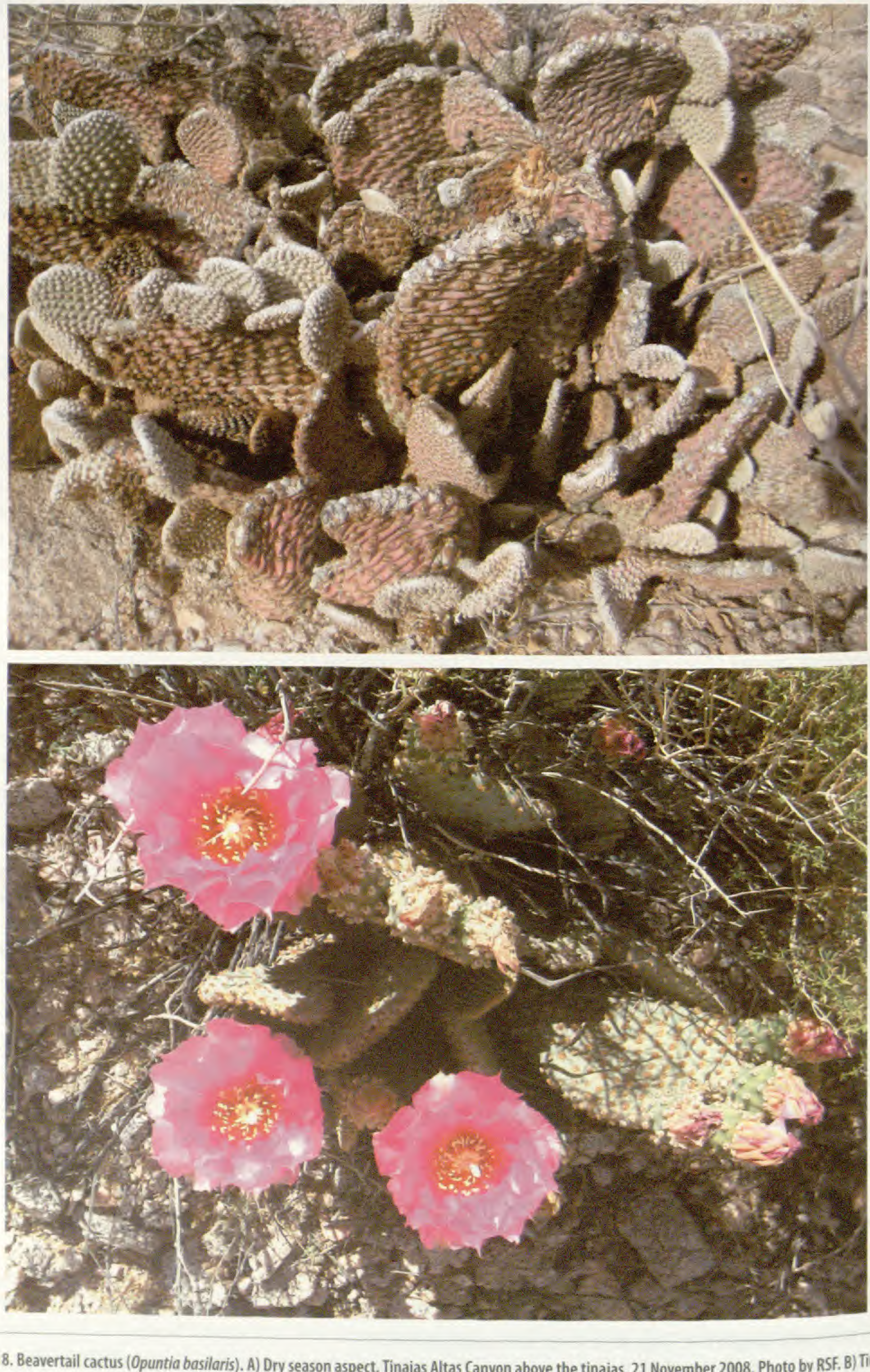

Fig. 18. Beavertail cactus (*Opuntia basilaris*). A) Dry season aspect, Tinajas Altas Canyon above the tinajas. 21 November 2008. Photo by RSF. B) Tinajas Altas Canyon just above the tinajas, 28 April 2010. Photo by JM.

Widespread, mostly on sandy soils in valley bottoms, washes, and bajadas.

Coyote Water, *Felger 04-22.* 1 mi N of Tinajas Altas Pass, W side of mts, *Van Devender 26 Mar 1983.*

Loeflingia squarrosa Nutt. [*L. squarrosa* subsp. *cactorum* Barneby & Twisselm.] SPREADING PYGMY-LEAF

Dwarf, cool-season annuals, quickly forming a slender taproot and small, very compact cushion-like mats about 1 (5) cm wide and less than 2.5 cm tall, and sometimes as small as 3 × 3 mm. Plants glandular pubescent, the stems at least partially obscured by needle-like rigid leaves. Flowers minute and hidden among the leaves.

Locally common on partially barren pediments of decomposed granite on the east side of Tinajas Altas Mountains.

Tinajas Altas, adjacent to parking area, a large but highly localized population among white granitic gravelly soil in open areas without other plants, *Felger 93-202.*

CHENOPODIACEAE, SEE **AMARANTHACEAE**

CRASSULACEAE—STONECROP FAMILY

Succulent annual or perennial herbs.

1. Tiny, delicate winter-spring annuals; leaves opposite, less than 0.5 cm long ______ **Crassula**
1. Thick-stemmed perennials; leaves alternate in a rosette, more than 2 cm long ______ **Dudleya**

Crassula connata (Ruiz & Pav.) A. Berger [*C. connata* var. *eremica* (Jeps.) M. Bywater & Wickens. *Tillaea erecta* Hook. & Arn.] PYGMY STONECROP

Diminutive winter-spring annuals, the plants succulent, green, reddish, or yellow-green. Leaves bead-like. Flowers white, minute.

Sandy and gravelly soils of bajada slopes and canyons, widespread following favorable rains.

Camino del Diablo, SSE of Raven Butte, *Felger 05-26.* Tinajas Altas, sandy soil near spinescent shrubs, *Felger 10-184.*

Dudleya arizonica Rose [*D. pulverulenta* (Nutt.) Britton & Rose subsp. *arizonica* (Rose) Moran. *Echeveria arizonica* (Rose) Kearney & Peebles] ARIZONA LIVEFOREVER

Perennials with very short, thick stems and rosettes of succulent leaves. Flowers yellow at base, yellow-orange above to red-orange towards tips; April and early May. Growing during cooler seasons and summer dormant. In late spring and early summer the larger leaves dry up and the remaining leaves shrivel and curl in over the center of the rosette, providing a close-fitting canopy over the dormant, central bud.

Mostly on bedrock slopes and cliffs, often north- and east-facing, commonly growing wedged in rock crevices. Common in the Tinajas Altas Mountains to peak elevations.

Tinajas Altas, *Vorhies 16 Apr 1924.* 1 mi N of Tinajas Altas, *Kurtz 1170.*

CROSSOSOMATACEAE—CROSSOSOMA FAMILY

Crossosoma bigelovii S. Watson. RAGGED ROCK-FLOWER

Unarmed shrubs to 1.5 m tall, evergreen or tardily drought deciduous. Flowers white and fragrant, mid-winter and early spring.

Often rooted in crevices in bedrock canyons or cliff faces in the Tinajas Altas Mountains. It has been established in the flora area for more than 43,000 years.

Borrego Canyon, vicinity of Borrego Tank, *Felger 93-194.* Tinajas Altas, *Webster 24254.* †Tinajas Altas, leaves, fruits, 4010–15,680 ybp (9 samples), & >43,000 ybp.

CUCURBITACEAE—GOURD FAMILY

Vining annuals and perennials, the stems with tendrils, the flowers unisexual. The aerial parts of members of this family are frost-sensitive.

1. Mostly growing during cooler times of the year; flowers less than 0.5 cm wide; fruits obovoid-oblique (bilaterally symmetric in cross section), ca. 1 cm long; seeds 1 (2) ______ **Brandegea**
1. Mostly growing with warmer weather; flowers more than 2 cm wide; fruits round, 8–9 cm wide; seeds many ______ **Cucurbita**

Brandegea bigelovii (S. Watson) Cogn. DESERT STAR-VINE

Annuals growing with cool-season rains, fall to spring, perishing in late spring; sometimes growing as early as September. Slender, herbaceous vines from a stout, carrot-shaped white root. Leaves thin and highly variable. Flowers small, white, and delicately fragrant.

Sandy-gravelly and loamy soils of washes and their floodplains, often seasonally festooning shrubs and trees in green curtains.

Coyote Water, *Felger 05-139.* Tinajas Altas, 5 Dec 1935, *Goodding 2092.* Tinajas Altas Pass, *Webster 24256.*

Cucurbita digitata A. Gray and **C. palmata** S. Watson

Perennials from a large, tuberous root, the vines sprawling across the desert or climbing through shrubs. Growing and flowering during the warmer months. Flowers large and yellow. Fruit a round gourd 8–9 cm in diameter, mottled green and white, becoming yellow with age.

The leaves of juvenile plants or the first growth of the season of *C. digitata* are essentially indistinguishable from those of both the juvenile and adult leaves of *C. palmata*, although leaves on "adult" *digitata* stems are distinctive (Felger 2000). These taxa are part of a complex of several closely related, arid-region cucurbitas in southwestern United States and northwestern Mexico. The Tinajas Altas region is in the area of contact between the "eastern" (Arizona and Sonora) *C. digitata* and the "western" (Arizona, California, Baja California) *C. palmata* (e.g., Bemis & Whitaker 1965, 1969). The two can be distinguished as follows:

Cucurbita plants in the Tinajas Altas Mountains look like *C. digitata*, while ones on the sandy soils of the Lechuguilla Valley bajada look like *C. palmata*. Even so, these *palmata*-like plants have leaf lobes not as broad and short as in populations farther west in southeastern California and in Baja California.

1. Leaves on reproductive ("adult") stems divided nearly, or sometimes entirely to the base with linear, finger-like segments or lobes with a few large teeth ____ C. digitata
1. Leaves with broad, mostly triangular and entire lobes ____ C. palmata

Cucurbita digitata A. Gray. Finger-leaf gourd, coyote gourd; *calabacilla, chichi coyota*; 'adavi, 'ad

Infrequent along arroyo bottoms in the Tinajas Altas Mountains.

Tinajas Altas, 5 Dec 1935, *Goodding 2090.* Frontera Canyon, 18 Mar 1998, *Felger* (observation). Tinajas Altas Pass, 1100 ft, washes, *Reeves R5408* (ASU).

Cucurbita palmata S. Watson. desert coyote-gourd

Infrequent on upper piedmont/bajada plains of the Lechuguilla Valley.

Camino del Diablo, E of Raven Butte, *Felger 01-584.*

EUPHORBIACEAE—Spurge Family

This large and diverse, mostly tropical and subtropical family is well represented in the Sonoran Desert. The flowers are small, mostly inconspicuous, and unisexual.

1. Shrubs.
    2. Stems slender, not succulent; sap not copious, not watery or blood-like; leaf margins crenulate-toothed ____ Acalypha
    2. Stems thick and semi-succulent; sap copious, watery or blood-like; leaf margins entire on short-shoot leaves or with a few broad lobes on long-shoot leaves ____ Jatropha
1. Annual or perennial herbs.
    3. Leaves alternate, opposite, or whorled; sap conspicuously milky; flowers in cyathia (small, compact, head-like inflorescences often about as wide as high) ____ Euphorbia
    3. Leaves alternate; sap not milky; flowers not in cyathia.
        4. Plants glandular-viscid and sticky, with simple hairs (glandular and non-glandular) ____ Acalypha
        4. Plants not glandular-viscid, the hairs 2-armed ____ Ditaxis

Acalypha californica Benth. [*A. pringlei* S. Watson] California copperleaf; *hierba del cáncer*

Shrubs or subshrubs with slender stems and glandular-sticky herbage; leaves gradually drought deciduous. Flowers small, generally reddish; flowering during warmer months with sufficient moisture.

Canyons, arroyo bottoms, and protected slopes in the Tinajas Altas Mountains.

Tinajas Altas, *Goodding 5 Dec 1935.*

DITAXIS

1. Subshrub perennials but often flowering in the first season; stems mostly erect and straight ____ D. lanceolata
1. Herbaceous, annuals or short-lived perennials; stems mostly ascending to spreading, or sometimes the main axis at first erect but the branches spreading and seldom straight.
    2. Leaves mostly ovate-elliptic, the tips mostly pointed, not truncate; seed surface usually with a reticulate pattern of shallow craters with fine radiating lines, hairs if present not sac-like and papillate; widespread but mostly not on sand flats and dunes ____ D. neomexicana

2. Leaves mostly obovate to spatulate, the tips mostly more or less truncate; seed surface smooth to sometimes faintly patterned, the narrower end often with sac-like or minutely papillate white hairs; mostly on sand flats and dunes **D. serrata**

Ditaxis lanceolata (Benth.) Pax & K. Hoffm. [*Argythamnia lanceolata* (Benth.) Müll. Arg.] NARROWLEAF SILVERBUSH

Sparsely to densely branched perennial herbs to subshrubs. Herbage silvery pubescent. Flowers inconspicuous, white and green, flowering during the warmer months.

Common and widespread; washes, canyons, bajadas, and rocky slopes to summit elevations. Often heavily browsed, probably by bighorn. It was in the Butler Mountains about 8200 years ago.

Tinajas Altas, *Felger 04-72*. Borrego Canyon, 16 Jun 1992, *Felger* (observation). †Butler Mts, leaves, fruits, 8160 ybp.

Ditaxis neomexicana (Müll. Arg.) A. Heller [*Argythamnia neomexicana* Müll. Arg.] NEW MEXICO SILVERBUSH

Non-seasonal annuals or small, short-lived perennials. Flowers green and white, small and inconspicuous.

Common and widespread; washes, valley plains, bajadas, and rocky slopes. It has been in the flora area since more than 8600 years ago.

Camino del Diablo, SE of Raven Butte, *Felger 04-10*. †Butler Mts, leaves, fruits, seeds, 3820 & 8570 ybp.

Ditaxis serrata (Torr.) A. Heller var. **serrata** [*Argythamnia serrata* (Torr.) Müll. Arg.] SAND SILVERBUSH

Non-seasonal annuals or perhaps short-lived herbaceous perennials. Leaves gray-green. Flowers green and white, small and inconspicuous. Similar to *D. neomexicana* but the plants more robust and the leaf tips generally truncate rather than pointed. Perhaps they are not distinct species.

Sandy soils, bajadas and washes. In the flora area seen at the south end of the Tinajas Altas Mountains and common in nearby areas.

Mexico border at mouth of Frontera Canyon, 18 Mar 1998, *Felger* (observation).

†**Ditaxis** sp./spp.

†Tinajas Altas, seeds, 5860 to 8255 ybp (3 samples).

EUPHORBIA—SPURGE

Annuals and perennial herbs with milky sap. The individual flowers are generally minute and borne in a cup-like structure, the cyathium, which looks somewhat like a single flower. The petal-like (petaloid) appendages of the cyathia of some species can be attractive and the whole structure is indicated here as the "flower." In Mexico the *Chamaesyce* are generally known as *golondrina*, the term for a swan, apparently in reference to the female flower on a curved, neck-like stalk, and the general Hia C'ed O'odham name is *v'ibam* (see *E. polycarpa*).

1. Plants not prostrate; leaves alternate below and opposite or whorled above, symmetrical, and narrowly linear, less than 3 mm wide Subgenus *Agaloma*: **E. eriantha**
1. Plants prostrate or not; leaves all opposite, asymmetric toward the base, linear or not Subgenus *Chamaesyce*
  2. Plants glabrous; stems orange; seeds smooth, flattened, more 2 mm long, not mucilaginous when wet **E. platysperma**
  2. Plants glabrous or pubescent; stems not orange; seeds smooth or sculptured, not flattened, not more than 1.2 mm long, mucilaginous when wet.
    3. Petaloid appendages absent (sometimes not developed in young cyathia or drought-stressed plants, these plants key out in both choices).
      4. Leaf margins entire or few toothed mostly near apex; involucral glands rounded, 0.1–0.15 mm wide; seeds 1–1.2 mm long, with transverse ridges **E. abramsiana**
      4. Leaf margins entire; involucral glands oval, 0.3 mm or more in width; seeds 0.8–1 mm long, the surfaces smooth **E. polycarpa**
    3. Petaloid appendages present
      5. Petaloid appendages with triangular, pointed segments, the cyathia thus appearing "star-shaped" **E. setiloba**
      5. Petaloid appendages entire, about as wide or wider than long, blunt-tipped, not pointed.
        6. Leaf margins entire to few toothed mostly near apex; involucral glands rounded, 0.1–0.15 mm wide; seed 1–1.2 mm long, with transverse ridges **E. abramsiana**
        6. Leaf margins entire; involucral glands oval, 0.3 mm or more in width; seeds 0.8–1 mm long, the surfaces smooth **E. polycarpa**

Euphorbia abramsiana L.C. Wheeler [*Chamaesyce abramsiana* (L.C. Wheeler) Koutnik] DESERT SANDMAT; GOLONDRINA

Small annuals, mostly prostrate, growing with hot-season rains and probably also with cool-season rain. Herbage often brownish or reddish. The minute cyathia, reduced petaloid appendages, and glabrous capsules are distinctive features.

Sandy and gravelly soils; washes and sandy flats of the Lechuguilla Valley.

Coyote Water, 25 Oct 2004, *Felger 04-44*. Coyote Wash at Camino del Diablo, 25 Oct 2004, *Felger 04-68*.

Euphorbia eriantha Benth. BEETLE SPURGE

Non-seasonal annuals mostly encountered in spring, occasionally short-lived perennials; often with a solitary or few-branched main axis and sparsely branched above, and sparse foliage. Flowers inconspicuous; ovary and capsule covered with short, white hairs.

Sandy, gravelly soils of washes and bajadas of the Lechuguilla Valley and scattered in canyons and slopes in the mountains.

Camino del Diablo, SE of Raven Butte, *Felger 04-12*. Canyon above Tinajas Altas, 18 Mar 1998, *Felger* (observation). Coyote Water, 25 Oct 2004, *Felger* (observation). Vicinity of Coyote Wash along Camino del Diablo, *Yeatts 3242* (CAB).

Euphorbia platysperma Engelm. ex S. Watson [*Chamaesyce platysperma* (Engelm. ex S. Watson) Shinners] DUNE SPURGE

Non-seasonal annuals to herbaceous perennials. Plants glabrous; stems orange, many and sprawling, with sand adhering to the glandular-sticky buried portions of the stems forming a sand jacket. Leaves elliptic to oblong or obovate, relatively thin, the midrib prominent. "Flowers" yellowish. Seeds smooth, flattened, markedly longer than wide (2.4 × 1.4 mm). The seeds are larger than most *Chamaesyce* species and not mucilaginous, unlike those of the other *Chamaesyce* in the flora area that become moderately or conspicuously mucilaginous when wet and adhere tenaciously to a substrate upon drying.

This species is rare in Arizona and California. It is a dune and sand soil endemic, common in the Gran Desierto dunes of northwestern Sonora, and also known from extreme northeastern Baja California, and Arizona on dunes and sand soil at the southwestern margin of the flora area west of Tinajas Altas Mountains near the Mexican border, and occasional waifs are recorded from southeastern California dunes (Felger 2000; Felger et al. 2007b).

NW corner of Yuma Dunes, 7.4 km N of Mexico border, *Douglas 876* (ASU).

Euphorbia polycarpa Benth. [*E. polycarpa* var. *hirtella* Boiss. *Chamaesyce polycarpa* (Benth.) Millsp.] DESERT SPURGE; *GOLONDRINA*; VI'IBAM

Plants highly variable: non-seasonal annuals, sometimes becoming reproductive a few weeks after germination, and also occurring as small perennials. "Flowers" maroon and white, or drought-stressed plants may fail to develop the white, petal-like appendages.

This is the most common and widespread euphorbia in the region. Sandy soils of washes and bajada-plains, and rocky slopes.

Camino del Diablo, SE of Raven Butte, *Felger 04-13*. Wash, ca. 2 mi SE of Tinajas Altas, *Felger 08-205*. Granitic hills, SW side of Tinajas Altas Mts, 10 Jan 2002, *Felger* (observation).

†**Euphorbia** cf. **polycarpa** &/or **E. micromera** Boiss. ex Engelm.

One or both of these species were in the region more than 10,000 years ago. Their seeds appear identical and the two taxa are distinguished by subtle differences in the cyathia.

†Butler Mts, capsules, seeds, 8160 & 10,360 ybp.

Euphorbia setiloba Engelm. ex Torr. [*Chamaesyce setiloba* (Engelm. ex Torr.) Millsp.] FRINGED SPURGE; *GOLONDRINA*

Non-seasonal annuals, especially with summer-fall rains. Plants glandular-pubescent, the herbage yellow-green during hotter months, otherwise reddish. Cyathia with seven tooth-like white or pink appendages (hence the specific name) giving the flower cluster a unique star-like look. The plants are frost-sensitive.

Widely scattered, probably mostly at low elevations; often in broad, sandy-gravelly washes, canyon bottoms, and bajadas.

Camino del Diablo, SE of Raven Butte, *Felger 04-14*. Wash, 2 mi SE of Tinajas Altas, *Felger 08-205*.

†**Euphorbia** sp./spp. (*Chamaesyce*)

One or more unidentified *Chamaesyce* were at Tinajas Altas at least 5,000 to more than 11,000 years ago.

†Tinajas Altas, capsules, 5940–11,040 ybp (4 samples).

Jatropha cuneata Wiggins & Rollins. DESERT LIMBERBUSH; *SANGRENGADO*; VA:S

Shrubs often 1–1.5 m tall, oozing blood-like sap when cut—hence the name *sangrengado* (dragon's blood). Leaves drought deciduous, appearing with rains at various seasons except during the coldest weeks or months. Flowers small and white, with rains from July to October. Stems sometimes freeze-damaged during severe winters.

Common and widespread on rocky slopes and upper bajadas south of Tinajas Altas Pass, uncommon or absent farther north. This was the most common plant for basket-making by the Hia C'ed O'odham. The one prehistoric record in the region is about 1250 years old.

Tinajas Altas, near base, *Harrison 6567*. Borrego Canyon, 3 Feb 1990, *Felger* (observation). †Tinajas Altas, 550 m, leaves, seeds, 1230 ybp.

FABACEAE—Legume Family

Annual or perennial herbs, shrubs, trees, or vines, many with nitrogen-fixing bacteria in root nodules. Leaves alternate and once- or twice-pinnately or palmately compound. The trio of *Olneya*, *Parkinsonia*, and *Prosopis* are the most important desert trees of the region and are significant nurse plants for an array of herbs and larger perennials including saguaros. These trees featured importantly in the economies of the local peoples for food, fuel, shelter, fiber, medicine, and provided some of the rare shade (e.g., Felger 2007; Felger & Moser 1985; Felger et al. 1992; Hodgson 2001; Rea 1997). The Sonoran Desert flora includes 281 legume species, or about 11% of the total flora, while legume species make up only 4% of our flora.

1. Trees and woody shrubs, often more than 1 m tall.
  2. Bark remaining green for multiple years; flowers yellow, caesalpinioid ________ **Parkinsonia**
  2. Bark not green as above; flowers yellow or not, mimosoid or papilionoid.
    3. Leaves once pinnate; flowers papilionoid.
      4. Trees mostly more than 3 m tall with woody trunks; herbage not gland-dotted; leaves with more than 5 leaflets; common ________ **Olneya**
      4. Shrubs not more than 1 m tall, scarcely woody; herbage gland-dotted; leaves with 3 or 5 leaflets; rare ________ **Psorothamnus**
    3. Leaves twice pinnate; flowers mimosoid.
      5. Spines straight; leaflets more at least 4.5 mm long; stamens 10; pods relatively thick, not conspicuously flattened, and with conspicuous mesocarp (pulp) ________ **Prosopis**
      5. Spines (actually prickles) recurved; leaflets 1.5–3 mm long; stamens more than 30; pods flattened (ribbon-like) and dry (without mesocarp, or pulp) ________ **Senegalia**
1. Annuals and herbaceous perennials, less than 1m tall; flowers papilionoid.
  6. Leaves with (3) 5–7 leaflets; flowers solitary or in umbels, yellow or orange and red ________ **Acmispon**
  6. Leaves with 5–23 leaflets; flowers in racemes, purple and white or pale lavender-pink.
    7. Herbage conspicuously gland-dotted; leaves pinnately compound; calyx lobes extending into awn-like plumose bristles; pods indehiscent, less than 3 mm long, 1-seeded ________ **Dalea**
    7. Herbage not gland-dotted; leaves digitately compound; calyx lobes not awned; pods dehiscent, 4 mm or more in length, with 2 or more seeds ________ **Lupinus**

Acacia, see **Senegalia**

ACMISPON

Annuals or herbaceous perennials. Leaves pinnate with 3–7 leaflets. Flowers yellow to red-orange, pea-like. Pods multiple seeded.

1. Perennials; stems firm and upright, the internodes notably longer than the leaves; flower stalks much longer than the leaves; flowers 1.5–2 cm long ________ **A. rigidus**
1. Winter-spring annuals; stems not firm, ascending or prostrate, the internodes usually not longer than the leaves; flowers nearly sessile or on peduncles shorter to slightly longer than the leaves; flowers less than 1 cm long ________ **A. strigosus**

Acmispon rigidus (Benth.) Brouillet [*Lotus rigidus* (Benth.) Greene. *Hosackia rigida* Benth.] Desert rock-pea

Perennial subshrubs with sparse foliage. Flowers 15–20 mm long, the corollas at first bright yellow, a red-orange nectar guide soon develops, and with age the entire corolla becomes red-orange.

Nearly throughout the Tinajas Altas Mountains, arroyos and canyons among boulders and rocky slopes, often east- and north-facing. Documented at Tinajas Altas from about 4000–10,800 years ago.

Tinajas Altas, *Harrison 3610*. Tinajas Altas, crevices in granite, 1400 ft, *Engard 925* (ASU). Surveyors Canyon, canyon bottom just below Surveyors Tank, *Felger 10-203*. Frontera Canyon, 18 Mar 1998, *Felger* (observation). †Tinajas Altas, fruits, seeds, 4010–10,750 ybp (7 samples).

Acmispon strigosus (Nutt.) Brouillet [*Hosackia strigosa* Nutt. *Lotus strigosus* (Nutt.) Greene var. *tomentellus* (Greene) Isely. *Ottleya strigosa* (Nutt.) D.D. Sokoloff] Hairy lotus

Winter-spring annuals, mostly low growing or prostrate; leaves succulent on well-watered plants. Flowers 7.5–9 mm long, the petals bright yellow with red nectar guidelines on the banner.

Washes and canyon bottoms, and soil pockets on rocky slopes.

Tinajas Altas, *Van Devender 9 Mar 1980*. Tinajas Altas Canyon, 19 Mar 1998, *Felger* (observation).

Cercidium, see **Parkinsonia**

Dalea mollis Benth. SILKY DALEA

Non-seasonal annuals; flowers small, purple and white.

Strangely, there are no modern records of this widespread desert annual from the core Tinajas Altas area although it occurs in adjacent areas. It was at Tinajas Altas about 5900–6000 years ago.

E margin of Davis Plain at base of Gila Mountain, W branch of Camino del Diablo, 965 ft, in rock crevices and nearby on sandy soil, *Felger 05-67.* †Tinajas Altas, fruits, 5860 & 5940 ybp.

Lotus, see **Acmispon**

Lupinus arizonicus (S. Watson) S. Watson [*L. arizonicus* subsp. *sonorensis* J.A. Christian & D.B. Dunn] ARIZONA LUPINE; *LUPINO*; TAS HA:HAG

Winter-spring annuals, the herbage sometimes semi-succulent. Flowers pale lavender-pink.

Widespread in lowland habitats, especially washes, and bajadas; also canyons in the Tinajas Altas Mountains to at least 1530 ft.

Tinajas Altas, *Van Devender 25 Mar 1983.* Tinajas Altas Pass, *Reeves R5400* (ASU). Surveyors Canyon, canyon bottom, *Felger 10-212.*

†**Lupinus** sp./spp.

Lupines are documented for the region for nearly 10,000 years.

†Butler Mts, fruits, calyx, seeds 740 & 3820 ybp. †Tinajas Altas, seeds, 1230–9900 ybp (9 samples).

Olneya tesota A. Gray. IRONWOOD; *PALO FIERRO*; HO'IDKAM

Large shrubs or trees, the trunks and limbs often massive, and the wood extremely hard. Leaves gradually deciduous in extreme drought and prior to flowering. Flowers pea-like, pale to dark pink-lavender; mass flowering in late April and May during years of sufficient rainfall; each tree and population might not flower each year.

Widespread along washes, major drainageways, bajada-plains, mountain canyons, and infrequent and usually of smaller stature on rocky slopes. A number of mighty ironwoods are scattered about the arroyo-wash between the Mesa del Muerto and the lower tinajas, and the largest known one in the region, in Coyote Wash, is more than 12 m tall with a massive trunk (Fig. 19). This species is one of the several most common and important trees in the region and one of the favorite foods of desert bighorn and many small mammals. *Olneya* is one of the longest-lived trees in the Sonoran Desert and a prominent nurse plant for numerous other plants (Turner et al. 1995). Desert ironwood has grown in the region for nearly 10,000 years, which is the oldest known record for this species anywhere.

Olneya was an important source of wood and fuel, and the seeds were variously prepared for food (Felger 2007). Many large, old ironwood stumps can be seen throughout the region. For example, numerous large ironwood stumps and limbs in Frontera Canyon appear to be axe- or saw-cut, and many such stumps were noted on the desert flats about 1.5 miles south of the Tinajas Altas site. The ironwood population has largely recovered from the extensive woodcutting in the nineteenth and first half of the twentieth centuries. Bryan (1925: 422) wrote that at Tinajas Altas, "A few palo verde or ironwood trees are still standing and may furnish horse feed, but the traveler should bring his own firewood."

Tinajas Altas, wash just E of the tinajas, *Felger 08-171.* Tinajas Altas Canyon, 19 Mar 1998, *Felger* (observation). Frontera Canyon, 18 Mar 1998, *Felger* (observation). †Butler Mts, spines, leaves, fruits, 740–8570 ybp (3 samples). †Tinajas Altas, twigs with spines, leaflets, 1230–9900 ybp (4 samples).

PARKINSONIA—PALO VERDE

Trees and large, heavy-branched shrubs with green bark and relatively soft wood. Leaflets small, the leaflets and leaves quickly drought deciduous, the leaflets often falling independently; leaves twice pinnate or appearing once pinnate. Flowers yellow, caesalpinioid, produced in prodigious quantities in spring. Pods ripening in early summer, indehiscent to tardily partially dehiscent, 1–several-seeded.

1. Twig tips not spinescent; solitary or paired axillary spines often present; leaves petioled, the leaflets mostly 5–9 mm long ________ **P. florida**

1. Twig tips spinescent; axillary spines none; petiole absent, leaves with two sessile pinnae, the leaflets mostly 1–3.3 mm long ________ **P. microphylla**

Parkinsonia florida (Benth. ex A. Gray) S. Watson [*Cercidium floridum* Benth. ex A. Gray] BLUE PALO VERDE; *PALO VERDE*; KO'OKOMADK, KALISP. **Fig. 15.**

One of the several larger tree species in the region, usually with a well-developed trunk. Flowers bright yellow; mass flowering in spring and sometimes sporadically in fall.

Blue palo verde trees are fairly common in canyon bottoms and the larger washes along the eastern side of the Tinajas Altas Mountains, such as the broad wash leading out of Borrego Canyon, and many of the small washes on the upper bajada. Only two or three blue palo verdes, however, were found between 2000 and 2006 in the wash below Tinajas Altas, the absence of more of the trees perhaps due to earlier woodcutting, but by 2008 even these trees were gone, apparently due to drought and firewood collecting by visitors. Although the soft wood is of poor quality for fuel, it was utilized because little else was available. The seeds served as food for people. The trees were common on the Davis Plain west of the Gila Mountains, although many of them perished during extreme drought of 2004 and 2005. Palo verdes and ironwoods were not seen along Coyote Wash in the vicinity of Coyote Water, yet palo verde is common and ironwood present only eight km south in La Jolla Wash. At the northern end of the study area, blue palo verde replaces foothill palo verde in certain unexpected circumstances, such among the basalt boulders of Raven Butte—hardly typical habitat, but the basalt is a veneer atop course granitic alluvium, and perhaps well drained and not so different from an arroyo. This species has been in the region for at least 8300 years.

Tinajas Altas, wash, *Van Devender 86-11*. Arroyo 2 mi SE of Tinajas Altas, *Felger 08-195*. Borrego Canyon, 16 Jun 1992, Felger (observation). Camino del Diablo, E of Raven Butte, 25 Oct 2004, *Felger* (observation). Canyon wash at NW side of Raven Butte, 30 Dec 2005, *Felger* (observation). †Butler Mts, twigs, spines, fruits, 740 & 3820 ybp. †Tinajas Altas, twigs, spines, 4010 & 8255 ybp.

Parkinsonia microphylla Torr. [*Cercidium microphyllum* (Torr.) Rose & I.M. Johnst.] FOOTHILL PALO VERDE, LITTLE-LEAF PALO VERDE; *PALO VERDE*; KEK CEHEDAGĪ

Small trees or large shrubs. Flowers pale yellow with a white banner petal; mass flowering in April and early May.

Upper bajadas on the east side of Tinajas Altas Mountains; canyons, washes, and rocky slopes from the base to higher elevations on all slope exposures in the mountains but scarce north of Tinajas Altas Pass. The seeds were a significant food resource for people.

Tinajas Altas Canyon, *Felger 08-177*. Frontera Canyon, 18 Mar 1998, *Felger* (observation).

Prosopis glandulosa Torr. var. **torreyana** (L.D. Benson) M.C. Johnst. [*P. juliflora* (Sw.) DC. var. *torreyana* L.D. Benson. *P. odorata* Torr. & Frém., sensu R. Palacios 2006] WESTERN HONEY MESQUITE; *MEZQUITE*; KUI

Trees and shrubs. Leaves appearing simultaneously in spring after the last freezing weather, the plants gradually become deciduous in winter. Leaves with one pair of pinnae. Flowers dull yellow; mass flowering April and May, and sporadically through early fall; pods mostly ripening in early summer and sporadically through fall.

Mesquites are concentrated along the larger drainageways where the largest trees occur, especially along Coyote Wash where the larger ones are about 8 m tall. Also in the wash below Tinajas Altas, and in the larger canyons and arroyos running out of the mountains. Only a few were found in the canyon above the Tinajas and none were seen at the higher elevations. Many animals consume the pods, which are a primary seasonal food for coyotes.

Mesquite was the single most useful plant in the Sonoran Desert; providing wood for construction, tools, utensils, and weapons, and was the preferred cooking fuel. The mesocarp of the pods was a major food resource. The roots were fashioned into cordage. The whitish gum is edible and was used medicinally, as was the black pitch oozing onto the bark. This black pitch was also used as dye (Felger 2007; Felger & Moser 1985).

Mesquites in the flora area have leaves with one pair of pinnae and the typically elongated and rather widely spaced leaflets characteristic of *P. glandulosa*, but some specimens are conspicuously pubescent like *P. velutina* rather than being glabrate or glabrous as in "typical" *P. glandulosa*. The Tinajas Altas population is within a broad area of mesquites of intermediate appearance (Felger 2000).

Coyote Water, *Felger 04-62*. Base of Tinajas Altas, *Harrison 6581*. 1 mi N of Tinajas Altas, 17 Apr 1948, *Kurtz 1175* [herbage pubescent]. Surveyors Canyon, canyon bottom below Surveyors Tank, *Felger 10-216*. Frontera Canyon, 18 Mar 1998, *Felger* (observation).

†Prosopis glandulosa &/or **P. velutina** Wooton. MESQUITE

Mesquite has been well established in the region for more than 18,750 years. The fossil specimens do not allow us to determine which of the two species were gathered by Ice Age packrats.

†Butler Mts, leaflets, 740 & 8160 ybp. †Tinajas Altas, spines, leaflets, endocarps, 1230–18,700 ybp (14 samples).

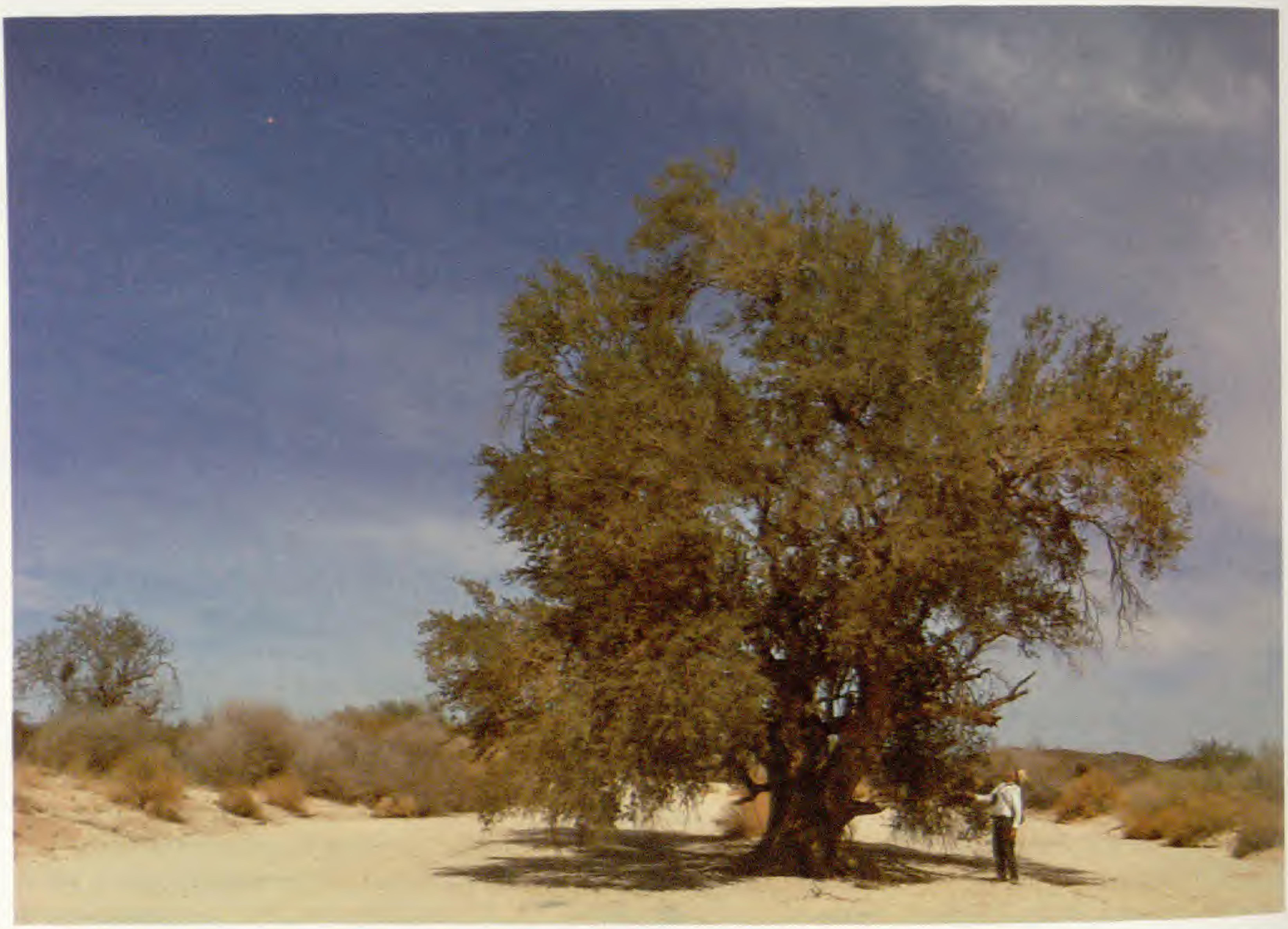

Fig. 19. An exceptionally large ironwood (*Olneya tesota*) in Coyote Wash. Vegetation scientist Peter Sundt is 2 m tall. 5 March 2011. Photo by JM.

Psorothamnus fremontii (Torr. ex A. Gray) Barneby [*Dalea fremontii* Torr. ex A. Gray] FREMONT'S DALEA

Shrubs less than 1 m tall, gland-dotted and generally pubescent (silvery strigose). Leaves odd-pinnate, with 3 or 5 leaflets, and leafless or essentially so in drought. Inflorescence a raceme, the flowers 7–9.5 mm long, pea-like and bright violet-purple. Pods indehiscent, 1-seeded, 7–10 mm long, with small glands forming longitudinal lines. [Description based on plants from farther north in Arizona and the Jepson Manual (Hickman 1993)].

A single shrub of this species was found at the north end of the Sierra de la Lechuguilla at the south end of the Lechuguilla Valley. Fremont's dalea is common farther north with three southern disjunct records: this one, one near the Colorado River in southeastern California collected in 1969, and one in Yuma collected in 1905 (e.g., Southwest Environmental Information Network 2011). This species occurs in the Sonoran and Mohave Deserts in California, Nevada, Utah, and Arizona, Sonora, and Baja California. Additionally, there is a single southern disjunct record of *P. arborescens* (Torr. ex A. Gray) Barneby var. *arborescens* from Puerto Peñasco in northwestern Sonora (*H.L. Cook in 1934* at DS/CAS; Barneby 1977: 33; Felger 2000).

The single specimen from the flora area was collected during a dry season—there were a few buds and no flowers. Two varieties are described: var. *fremontii* generally grows on sedimentary rocks, while var. *attenuatus* Barneby is on granitic and volcanic rocks (Turner et al. 1995). This species, however, may not be distinct from *P. arborescens*, both of which have somewhat similar distributions primarily north of the Sonoran Desert in dry regions of California, Nevada, Arizona, and Colorado (Barneby 1977; Turner et al. 1995).

Rounded hills along La Jolla Wash, between the Sierra de la Lechuguilla and the Tinajas Altas, UTM 2 18 915 E, 35 73 341 N, Zone 12, WGS 84, 1050 ft, shrub about 0.8 m tall, uncommon, with *Larrea*, *Ambrosia dumosa*, *Fagonia californica*, & *Parkinsonia microphylla*, *Sundt, MacKinnon, & Malusa 2 Apr 2011*.

Senegalia greggii (A. Gray) Britton & Rose [*Acacia greggii* A. Gray] CATCLAW; *UÑA DE GATO, GATUÑO*; 'U:PAD

Large, irregularly branched shrubs or small trees, the twigs bearing sharp, recurved internodal prickles (spines). Leaves gradually winter deciduous. Flowers pale yellow, in spring and occasional at other seasons; pods flattened, ribbon-like, and usually curved or curled, and ripening in early summer.

Lechuguilla Valley in larger washes and less often along smaller drainageways of the bajada, and Tinajas Altas Mountains in washes, canyons, and rocky slopes, especially east- and north-facing, from low to high elevations. Catclaw is one of the favorite foods of desert bighorn (Russo 1956). Packrat collections show it has been in the Tinajas Altas Mountains for more than 43,000 years.

Coyote Water, *Felger 04-21.* Wash just E of Tinajas Altas, *Felger 08-188.* Canyon above Tinajas Altas, 26 Oct 2004, *Felger* (observation). †Butler Mts, stem prickles, leaflets, fruit fragments, 740 to 8160 ybp (3 samples). †Tinajas Altas, twigs (prickles), leaves, 1230 to 11,040, & >43,000 (14 samples).

FOUQUIERIACEAE—OCOTILLO FAMILY

Fouquieria splendens Engelm. subsp. **splendens.** OCOTILLO; *OCOTILLO*; MELHOG. **FIGS. 9 AND 11.**

Unique, long-lived shrubs with wand-like spiny branches arising from a very reduced trunk. Short-shoot leaves appear at almost any time of year following a ground-soaking rain except during freezing weather, and are quickly shed as the soil dries or with freezing weather. Long-shoots are produced during times of warm or hot weather and high soil moisture. Flowers red-orange, generally in spring.

Widespread; sandy soils of upper bajadas and rocky slopes to summit elevations. Ocotillo served as a framework for the traditional Hia C'ed brush house. The flowers provide sweet nectar for trail snacks. "A 1989 survey…reported the presence of ocotillo sticks, identified as 'spiritual sticks' in a rockshelter near Tinajas Altas" (Rankin 2000: xxxv).

The oldest Sonoran Desert records are from the late Holocene, about 4500 years ago in the Hornaday Mountains in the Pinacate region of nearby northwestern Sonora (Van Devender et al. 1990a). Considering the ecological amplitude (range of habitats) and wide geographic range of this species, its apparent late arrival and rarity in packrat midden assemblages in the flora area is somewhat surprising.

Camino del Diablo, SE of Raven Butte, *Felger 04-15.* Tinajas Altas Canyon, *Felger 08-181.* Tinajas Altas Mts, near the summit, 26 Oct 2004, *Felger* (observation). †Butler Mts, stem fragment with spines, 740 ybp.

GERANIACEAE—GERANIUM FAMILY

ERODIUM—STORKS BILL

Winter-spring annuals with small, lavender-pink flowers. The long, corkscrew beak on each fruit segment uncoils when moistened and screws the sharp-pointed and heavier seed-bearing end into the ground.

1. Leaf blades pinnately dissected, much more than twice as long as wide, the petiole shorter than the blade ____________ **E. cicutarium**
1. Leaf blades ovate, often 3-lobed or 3-parted, less than twice as long as wide, the petiole longer than the blade __________ **E. texanum**

***Erodium cicutarium** (L.) L'Hér. ex Aiton. FILAREE, HERONS-BILL; *ALFILERILLO*; HOHO'IBAD

Not widespread in the flora area although common in nearby areas, especially in disturbed sites. Documented in the vicinity of Coyote Water and rare along the canyon above the Tinajas Altas. Native to the Mediterranean region and widely naturalized in the New World.

Coyote Water, *Felger 05-143.* Tinajas Altas Mts, above the tinajas, among rocks, rare, grazed, 19 Mar 1998, *Felger* (observation).

Erodium texanum A. Gray. FALSE FILAREE, DESERT STORK'S BILL

Widespread and common; washes, bajadas, plains, and sandy flats. It has been in the flora area for at least ten millennia.

Camino del Diablo, SSE of Raven Butte, *Felger 05-34.* †Butler Mts, fruit, 10,360 ybp. †Tinajas Altas, fruit, 8970 ybp.

HYDROPHYLLACEAE, SEE **BORAGINACEAE**

KOEBERLINIACEAE—ALLTHORN FAMILY

†**Koeberlinia spinosa** Zucc. CRUCIFIXION THORN, ALLTHORN; *CORONA DE CRISTO*

Spinescent woody shrubs, essentially leafless.

The nearest population occurs along the northeastern border of Organ Pipe Monument, except for a single known shrub from the Pinacate Region (Felger 2000). There is one fossil record for it in the Butler Mountains.

†Butler Mts, twig, 10,360 ybp.

KRAMERIACEAE—RATANY FAMILY

KRAMERIA

Small shrubs with small drought-deciduous leaves; reported as root parasites on other shrubs. Flowers bilaterally symmetrical, purple and yellow, and attractive; the 5 sepals are petal-like and the 5 petals modified into a landing-pad lip and two slab-like, thick elaiphores. Female *Centris* bees are the pollinators, gathering saturated fatty acids from the elaiphores (Simpson & Neff 1977).

1. Branches mostly straight and without knotty spur-branches; the 3 upper petals distinct (free), the blades near orbicular; spines of fruit with barbs in a terminal cluster ____ K. bicolor
1. Branches tough and knotty with many short spur-branches; claws of the 3 upper petals fused toward base, the blades lanceolate; spines of fruit with barbs alternate along upper part of shaft ____ K. erecta

Krameria bicolor S. Watson, 1886 [*K. grayi* Rose & Painter, 1906] WHITE RATANY; *CÓSAHUI*; EDHO, HE:D

Sprawling shrubs. Flowers magenta-purple (deep rose), at various seasons following sufficient rainfall, especially in spring.

Common and widespread through most of the lowlands of the region, especially in sandy to gravelly soils of washes, plains, and bajadas, and sometimes on rocky slopes.

Camino del Diablo, SE of Raven Butte, *Felger 04-16*. Tinajas Altas, canyon below tanks and on rocky slopes, 19 Mar 1998, *Felger* (observation).

Krameria erecta Willd. ex Schult. [*K. parvifolia* Benth.] LITTLE-LEAF RATANY, RANGE RATANY; *CÓSAHUI*

Dwarf woody shrubs with knotty short-shoots. Flowers bright magenta-purple, at various seasons following sufficient rainfall.

Scattered on sparsely vegetated granitic-gravelly dissected bajadas, often with *K. grayi*. It has been in the Butler Mountains for more than 8200 years.

0.3 mi SE of Tinajas Altas, *Felger 08-191*. Butler Mts, 27 Mar 1983, *Van Devender* (observation). †Butler Mts, leaves, fruits and spines from fruits, 740 & 8160 ybp.

LAMIACEAE—MINT FAMILY

Shrubs or perennials. Leaves opposite. Flowers bilaterally symmetrical, violate, blue, or white and lavender.

1. Herbaceous or scarcely suffrutescent perennials ____ Teucrium
1. Shrubs, at least the lower branches woody.
   2. Plants densely pubescent with branched white hairs; calyx not bag-like, the calyx lobes toothed ____ Hyptis
   2. Plants appearing glabrous or with simple (unbranched) hairs; calyx not toothed, the fruiting calyx inflated and hollow like a bag ____ Scutellaria

Hyptis albida Kunth [*H. emoryi* Torr.] DESERT LAVENDER; *SALVIA*

Many-stemmed shrubs, the foliage usually whitish. Flowers small, fragrant, and violet, produced in large quantities through much of the year except during times of freezing weather and extreme drought, and attracting hummingbirds.

Widespread, especially in washes, also in canyon bottoms and on rocky slopes to the mountain summit. The fossil record for the flora area extends to 8700 years.

Hyptis emoryi seems best regarded as a synonym of *H. albida* (see Felger 2007; Martin et al. 1998; Felger & Wilder 2012). The Sonoran Desert populations tend to be more densely white-pubescent than those of *H. albida* from non-desert regions farther south in Mexico, but the variation is continuous. The leaves of well-watered desert plants, even in the Tinajas Altas region, especially following favorable, warm-season rains, can be much larger, greener (sparser pubescence), and thinner than dry-season leaves and can resemble leaves of typical non-desert plants (Felger 2000; Turner et al. 1995). Several varieties of *H. emoryi* have been described and across the large geographic range there is considerable variation in leaf shape that may have some taxonomic value.

1 mi N of Tinajas Altas, *Kurtz 1161*. Tinajas Altas Pass, *Reeves R-5421* (ASU). Frontera Canyon, 18 Mar 1998, *Felger* (observation). Camino de Diablo, E of Raven Butte, 26 Nov 2001, *Felger* (observation). Tinajas Altas Canyon, *Felger 08-183*. †Butler Mts, twigs, leaves, fruits, 740–8570 ybp (3 samples). †Tinajas Altas, leaves, calyces, seeds, 1230–8700 ybp (6 samples).

†**Monardella arizonica** Epling. ARIZONA MONARDELLA

Bushy, herbaceous or subshrub perennials.

This mint is documented from the Tinajas Altas Mountains from about 9000 to more than 43,000 years ago. The nearest present-day population occurs in canyons in the Ajo Mountains in Organ Pipe Monument. It occurs elsewhere in southern and western Arizona, but generally above the desert.

†Tinajas Altas, involucres, fruits, 8979–18,700 (9 samples), & >43,000 ybp.

†Salvia mohavensis Greene. MOJAVE SAGE

Broad, spreading shrubs with woody stems.

The fossil record in the flora area extends from about 9300 to more than 43,000 years. It was widespread in the Sonoran Desert region through the late Pleistocene. The nearest present-day occurrences are relictual populations at higher elevations in the Sierra Pinacate in northwestern Sonora, and more extensive populations in the Copper, Maricopa, and Mohawk Mountains in southwestern Arizona. Mojave and Sonoran deserts in southeastern California, southern Nevada, western Arizona, and northwestern Sonora.

†Butler Mts, twigs, leaves, 10,360 & 11,060 ybp. †Tinajas Altas, leaf fragments, calyces, 9230–18,700, & > 43,000 ybp (12 samples).

Scutellaria mexicana (Torr.) A.J. Paton [*Salazaria mexicana* Torr.] BLADDER-SAGE

Shrubs usually with sparse foliage, the stems interlacing and branching at right angles, twigs often rigid and almost spinescent. Flowers white and blue; mass flowering at various seasons following rains. The calyx enlarges as the fruit develops to become hollow like a paper bag.

Tinajas Altas Mountains, on steep rocky slopes, especially north-facing exposures at higher elevations, canyons, and upper bajadas.

Tinajas Altas, Camino del Diablo, canyon bottom, 1000 ft, 28 Oct 1937, *Gentry 3524*. Tinajas Altas Mts, canyon bottom in upper canyon, 0.4 km SW from the uppermost of tinaja, *Felger 04-90*.

Teucrium glandulosum Kellogg. DESERT GERMANDER

Herbaceous, somewhat bushy perennials. Flowers (corollas) relatively large (1.8–2.5 cm long) and attractive, white with lavender markings.

Shaded canyon bottoms in at least several mountains in Cabeza Prieta Refuge, one record in Organ Pipe Monument, and one in Coyote Wash in the Tinajas Altas region, but probably more widespread in the region. The Coyote Wash habitat is unusual for this species—elsewhere it is found in rocky habitats. In the United States known otherwise only from the Castle Dome, Coyote, and Mohawk Mountains in western Arizona and California where it is rare. Also northwestern Sonora and both Baja California states. This is one of the few species in this large genus confined to a desert.

Coyote Wash at Camino del Diablo, clay-like soil in dense mesquite brush, *Felger 02-14*.

LOASACEAE—STICKLEAF FAMILY

Annuals or perennials with silicified or calcified, barbed hairs (the barbs usually in whorls), these hairs resulting in the leaves and fruits sticking like Velcro.

1. Annuals or short-lived herbaceous perennials; leaves not entire, often toothed; flowers orange, yellow, or silvery ______ **Mentzelia**
1. Shrubs or subshrub perennials; leaf margins entire; flowers white ______ **Petalonyx**

MENTZELIA—STICKLEAF; *PEGA PEGA*

Spring or summer annuals, and sometimes herbaceous perennials.

1. Stems markedly slender; petals less than 8 mm long; flowers and capsules sessile; capsules linear but slightly narrowed towards the base, more than 5 times longer than wide ______ **M. albicaulis**
1. Stems not especially slender; petals more than 8 mm long; flowers and capsules pedicelled; capsules to about 2 times longer than wide, not linear.
    2. Caudex often thickened, the stems not woody; larger leaves (5.5) 9–15 cm long, in a basal rosette; petals seemingly 10; seeds 3.3–3.5 mm long ______ **M. longiloba**
    2. Caudex not especially thickened, the lower stems often woody like a dwarf shrub; larger leaves (1.8) 2.5–6.5 cm long, on the stems (cauline; the basal rosette very quickly withering in first season); petals 5 (the larger staminodes petal-like but clearly narrower than the petals); seeds 2.4–3.1 mm long ______ **M. puberula**

Mentzelia albicaulis (Douglas ex Hook.) Douglas ex Torr. & A. Gray [This species complex includes **M. desertorum** (Davidson) H.J. Thomps. & J.E. Roberts] WHITESTEM BLAZING STAR

Cool-season annuals. Flowers bright yellow, sometimes with a dark orange or reddish center.

Sandy and gravelly soils of the bajadas, arroyos, and washes. *M. desertorum* is distinguished on technical features.

Butler Mts, dunes, *Van Devender 27 Mar 1983*. W end of pass just N of Tinajas Altas, *Van Devender 6 Mar 1983.*

Mentzelia longiloba J. Darl. var. **yavapaiensis** J.J. Schenk & L. Hufford [*M. multiflora* (Nutt.) A. Gray subsp. *longiloba* (J. Darl.) Felger. BLAZING STAR; *PEGAPEGA*

Cool-season annuals and perhaps sometimes short-lived perennials. Flowers bright yellow.

Lower canyons and washes in the Tinajas Altas Mountains; apparently not common in the flora area.

Frontera Canyon, 18 Mar 1998, *Felger* (observation).

Mentzelia puberula J. Darl. SILVER BLAZING STAR

Facultative annuals to short-lived perennials, the plants often bushy; leaves often silvery gray-green. Flowers pale yellow, spring and summer with rains.

Canyons and rocky slopes; widely scattered but seldom common. A fossil from the Butler Mountains dates from about 3800 years ago.

Butler Mts, *Van Devender 27 Mar 1983*. Tinajas Altas, cliff face, *Reichenbacher 480*. †Butler Mts, twigs, seeds, 3820 ybp.

Petalonyx linearis Greene. NARROWLEAF SANDPAPER PLANT

Small, densely branched, rounded shrubs, usually less than 0.5 m tall. Flowers white; flowering at least in March and April.

Localized on widely scattered arid, gravelly-sandy washes and rocky slopes. It is documented for the flora area for 9 millennia.

Tinajas Altas, 1 Dec 1938, *Goodding 5335*. Tinajas Altas Mts, 1.7 km WNW of Tinajas Altas Peak, wash of granitic sand and rocks, infrequent, 340 m, *Baker 13307* (ASU). †Tinajas Altas, leaves, 1230 & 9230 ybp.

MALVACEAE—MALLOW FAMILY

1. Fruit a capsule of 5 persistent segments (carpels) spreading open at maturity, the carpels splitting open but remaining attached, the lower and upper portion of each segment essentially similar; perennials __________ Hibiscus
1. Fruit a schizocarp, the segments (mericarps) separating at maturity, the upper and lower portion of each segment markedly dissimilar; the lower chamber reticulate, the upper part with flared membranous wings.
    2. Tall skinny shrubs; floral bracts absent; petals bright yellow-orange or pink __________ Horsfordia
    2. Annuals and bushy perennials; floral bracts 3 per flower; petals orange or red-orange __________ Sphaeralcea

†Abutilon sp./spp.

This genus is documented for the flora area from 5900 to about 11,000 years ago. Three species of small shrubs in this genus occur in Cabeza Prieta Refuge: *A. incanum* (Link) Sweet, *A. malacum* S. Watson, and *A. palmeri* S. Watson; and a fourth one, *A. abutiloides* (Jacq.) Garke ex Britton & P. Wilson, occurs in Organ Pipe Monument, but none presently occur in the flora area.

†Tinajas Altas, mericarp fragments, 5860–11,040 ybp (3 samples).

Hibiscus denudatus Benth. var. **denudatus.** ROCK HIBISCUS

Perennial subshrubs. Corollas white to pinkish with maroon spots in the center, flowering at various seasons, especially during warmer months.

Widespread and common in the Tinajas Altas Mountains; pediments, canyons, and slopes to higher elevations. This hibiscus has been in the flora area for at least 15,700 years.

1 mi N of Tinajas Altas, *Kurtz 1157*. Tinajas Altas, ridge above tanks, 1420 ft, *Felger 04-91*. †Butler Mts, stems, leaf fragments, 740 & 8570 ybp. †Tinajas Altas, leaf fragments, seeds, 5860–15,680 ybp (5 samples).

HORSFORDIA—VELVET MALLOW

Tall, slender and sparsely branched shrubs. Flowering at various seasons except during coldest and driest weather.

1. Petals pinkish or sometimes nearly white when fresh, drying bluish to pale lavender; larger leaves mostly broadly ovate and cordate (heart-shaped); mericarps 1-seeded __________ H. alata
1. Petals orange when fresh; larger leaves mostly lanceolate and not cordate at base; mericarps 2 (3?)-seeded __________ H. newberryi

Horsfordia alata (S. Watson) A. Gray. PINK VELVET-MALLOW

Spindly shrubs (1.7) 2.5–4 m tall. Flowers pale lavender-white to pink, drying bluish to pale lavender.

Small to large washes in upper bajadas, canyons, and rocky slopes to higher elevations.

Large arroyo in front of the Tinajas, *Felger 04-73*. 1 mi N of Tinajas Altas, *Kurtz 1158*. Observations: Camino del Diablo, E of Raven Butte, 10 Jan 2002, *Felger*; Granitic hills at SW side of Tinajas Altas range, 10 Jan 2002, *Felger*.

Horsfordia newberryi (S. Watson) A. Gray. Orange velvet-mallow

Few-branched shrubs to 2.5+ m tall, often considerably shorter. Flowers bright yellow-orange.

Canyons and rocky slopes in the mountains.

Borrego Canyon, 16 Jun 1992, *Felger* (observation).

SPHAERALCEA—Globemallow; *mal de ojo*

1. Annuals (sometimes may appear perennial), often taller than wide; mericarps (capsule segments) 1-seeded, the dehiscent section short and stubby, less than half as long as the body (indehiscent portion) ____ **S. coulteri**
1. Perennials; mericarps 2- or 3-seeded, the dehiscent section more than half as long as the body.
   2. Mostly globose bushes, often at least as broad as tall; leaf blades usually as wide as long, more or less rounded to ovate; petals orange; mericarps 4–5.5 mm long ____ **S. ambigua**
   2. Plants often as tall to much taller than broad; leaf blades usually conspicuously longer than wide; petals orange to red-orange; mericarps 2.7–4.3 mm long ____ **S. emoryi**

Sphaeralcea ambigua A. Gray subsp. **ambigua.** Desert globemallow; *mal de ojo*

Bushy perennials, slightly woody at the base. Flowers orange; various seasons, especially spring.

Washes, upper bajadas, canyons, and rocky slopes, and also on well-drained soils of valley plains.

Tinajas Altas, *Felger 04-78.* Canyon below Raven Butte Tank, *Felger 10-240.* Frontera Canyon, 18 Mar 1998, *Felger* (observation).

Sphaeralcea coulteri (S. Watson) A. Gray [*S. orcuttii* Rose] Annual globemallow; *mal de ojo*; hadam tatk, ñiatum

Cool-season annuals and sometimes also growing with summer rains; highly variable in size, from less than 10 cm to 1.8 (2) m tall; sometimes appearing perennial and perhaps surviving one year or more. Flowers orange.

Seasonally common, mostly on valley floors, bajadas, and lower-elevation canyons. Robust, large plants, mostly on sandy soils, have been called *S. orcuttii*; other than the size of the plant, there are no apparent differences (Felger 2000).

Coyote Water, banks of wash, 1.5–1.8 (2) m tall, many, few-branched erect stems, *Felger 05-141.* High Tanks Gate, *Felger 98-111.* Camino del Diablo at Coyote Wash, 10 Jan 2001, *Felger* (observation).

Sphaeralcea emoryi Torr. ex A. Gray. Emory globemallow; *mal de ojo*

Annuals or short-lived perennials. Flowers orange to red-orange; spring and summer-fall rainy seasons.

Locally in fine-textured soils at the south end of Coyote Wash in the Lechuguilla Valley.

Camino del Diablo at Coyote Wash, localized in the mesquite "forest," *Felger 10-167.*

†**Sphaeralcea** sp./spp. (may be, or includes, *S. ambigua*)

Globemallows have been in the region for at least 11 millennia.

†Butler Mts, twigs, leaf fragments, mericarps, 740–11,250 ybp (4 samples). †Tinajas Altas, leaf fragments, mericarps, seeds, 4010–10,950 ybp (10 samples).

MARTYNIACEAE—Devil's Claw Family

Proboscidea altheifolia (Benth.) Decne. Desert devil's claw; *cuernitos, uña de gato*; ban ʼihugga

Strongly scented, herbaceous perennials from a deeply buried, large, tuberous root. Flowers showy, often 4 cm long, yellow with yellow-orange and bronze markings; growing and flowering with hot weather.

Sandy to silty soils of washes, floodplains, and valley plains.

Camino del Diablo, SE of Raven Butte, *Felger 04-18.*

MOLLUGINACEAE—Carpetweed Family

***Mollugo cerviana** (L.) Ser. Thread-stem carpet-weed, Indian chickweed

Diminutive summer annuals. First leaves in a basal rosette, which is unusual among desert summer annuals. Seeds snail-shaped with dark ridges (striae) on the dorsal side.

Sandy soils along Coyote Wash in the Lechuguilla Valley. Widespread in the Sonoran Desert and elsewhere in southwestern North America and Mexico; reported as native to the Old World and not native in the New World.

Coyote Water, *Felger 04-50.*

NYCTAGINACEAE —Four O'clock Family

Annual or perennial herbs or subshrubs. Sepals petal-like, the petals none. Fruits 1-seeded and achene- or nut-like, enclosed by the calyx tube and technically an anthocarp, the collective structure here called the "fruit."

Abronia flowers are open all day, but among the other seven species the flowers open in the early morning and collapse with daytime heat

1. Perennials; involucral bracts united into a persistent tube with 5 teeth; fruits rounded, nearly smooth **Mirabilis**
1. Annuals or short-lived perennials; involucral bracts separate, 1 to 5, sometimes reduced and/or soon deciduous; fruits not rounded and smooth—variously winged, angled, club-shaped, or grooved.
    2. Spring annuals; flowers very showy, in clusters (3) 4–5 cm wide; fruits 7–9 mm long (including the wings), with 5 conspicuous wings **Abronia**
    2. Annuals or perennials; flowers or flower clusters less than 2.5 cm wide; fruits not 5-winged.
        3. Stems slender, weak, and prostrate-trailing; flowers in clusters of 3, the cluster resembling a single flower; fruits with a single deep cavity formed by a pair of inrolled wings **Allionia**
        3. Stems erect to spreading, sometimes decumbent or prostrate but not trailing; flowers often clustered but each flower conspicuously separate; fruits with 4 or 5 furrows or grooves **Boerhavia**

Abronia villosa S. Watson var. **villosa.** SAND-VERBENA; *VERBENA DE LA ARENA*

Cool-season annuals; highly variable in size. Flowers diurnal, showy, very fragrant, pinkish purple to pale magenta. Fruits winged and beaked in a globose cluster.

Common and widespread on sandy plains and dunes at the western margin of the flora area near the base of the Butler Mountains. Although not documented elsewhere in the flora area, it is common and widespread on sandy soils in many nearby areas.

Butler Mts, *Van Devender 27 Mar 1983.*

Allionia incarnata L. [*A. incarnata* var. *nuda* (Standl.) Munz. *A. incarnata* var. *villosa* (Standl.) Munz] WINDMILLS, TRAILING FOUR-O'CLOCK

Short-lived perennials with slender, trailing stems, and also flowering in the first season. Flowers clustered in trios resembling a single flower, violet-rose or magenta; flowering non-seasonally in warmer months with sufficient soil moisture.

Widespread across the flora area in many habitats including gravelly floodplains, washes, canyons, flats, and rocky slopes.

Coyote Water, *Felger 04-23.* Camino del Diablo E of Raven Butte, *Felger 01-583.* Tinajas Altas Pass, *Reeves R5415* (ASU).

BOERHAVIA—SPIDERLING; *JAUNILIPIN*

Summer annuals and one perennial; the plants at first usually upright, later often spreading and becoming decumbent or even prostrate. Flowers open in the early morning and collapse with daytime heat.

1. Perennials or sometimes annuals; flowers dark red-purple; fruits sticky and densely pubescent with glandular hairs **B. coccinea**
1. Hot weather annuals; flowers white or pale pink; fruits glabrous, not sticky (the stems and flowering branches may be sticky).
    2. Flowers in umbellate or subumbellate clusters **B. erecta**
    2. Flowers on elongated racemose branches.
        3. Fruits 2.1–2.5 (2.7) mm long, slender (narrowly obovate), 5-angled or ridged, the furrows mostly narrow to nearly closed **B. spicata**
        3. Fruits 2–3 mm long, chunky (broadly obovate), all or mostly 4-angled, the furrows broad, open, and roughened inside **B. wrightii**

***Boerhavia coccinea** Mill. [*B. caribaea* Jacq.] SCARLET SPIDERLING

Sprawling, herbaceous perennials and also flowering in the first season, growing and reproductive in warmer months with sufficient soil moisture. Flowers small and bright red-purple, remaining open longer in the day than the other boerhavias in the region. Fruits glandular-pubescent.

Localized and well established at the base of the tinajas; not seen elsewhere in the flora area. Characteristic of disturbed sites regionally. This weedy species, now cosmopolitan in distribution, is probably native in southwestern North America but does not seem to be native in the Tinajas Altas and nearby regions (Felger 2000).

Tinajas Altas, near the lower tinaja: 15 Jun 1992, *Felger 92-609*; 29 Nov 2001, *Felger 01-582*; 28 Mar 2010, *Felger 10-180.*

Boerhavia erecta L. ERECT SPIDERLING; *JUANTILIPIN*; MAKKUMĨ HA-JEVED

Summer annuals; herbage glabrous or with minute hairs, the flowering branches with glandular-sticky bands. Flowers whitish to pale pink, in umbellate or subumbellate clusters. Fruits 5-angled.

Documented along Coyote Wash.

Coyote Water, *Felger 04-28.*

Boerhavia spicata Choisy [*B. coulteri* (Hook. f.) S. Watson. *B. coulteri* var. *palmeri* (S. Watson) Spellenb. *B. spicata* Choisy var. *palmeri* S. Watson] Palmer's spiderling; *juantilipín*

Summer annuals; flowering branches conspicuously glandular-sticky, sticking to shoes, socks, and pant legs. Flowers very small, white to pale pink, on racemose branches. Fruits 5-angled.

Various habitats: sandy to rocky soils; washes, bajadas, flats, and slopes; widespread and often very common.

Coyote Water, *Felger 04-29.*

Boerhavia wrightii A. Gray. Large-bract spiderling

Summer annuals, densely glandular sticky including the flowering branches. Flowers pinkish white to pink, on racemose branches. The plants are often rather robust and the floral bracts, flowers, and fruits are larger than those of the other boerhavias in the region. Fruits 4-angled.

Sandy to rocky soils in many habitats; seasonally common and nearly ubiquitous across the flora area. There is a specimen about 8200 years old from the Butler Mountains.

Camino del Diablo, SE of Raven Butte, *Felger 04-08.* Coyote Water, *Felger 04-30.* Tinajas Altas, 26 Oct 2004, *Felger* (observation). †Butler Mts, fruit, 8160 ybp.

MIRABILIS—Four O'clock

Herbaceous perennials; flowers white or pale pink, collapsing with daytime heat, usually before mid-morning.

1. Involucres 6–9 mm long, the lobes 2–3(–4) mm long **M. laevis**

1. Involucres 10–15 mm long, the lobes 5–9 mm long **M. tenuiloba**

Mirabilis laevis (Benth.) Curran var. **villosa** (Kellogg) Spellenb. [*M. bigelovii* A. Gray] Desert four o'clock

Herbaceous perennials, with glandular-pubescent herbage. Flowers white or pale pink, flowering at various seasons.

Widely scattered on rocky slopes to higher elevations, canyons, washes, valley plains, and bajadas. There is a specimen about 11,100 years old from the Butler Mountains.

Borrego Canyon, canyon slopes, *Felger 92-614.* Surveyors Canyon, *Felger 10-199.* Tinajas Altas, *Gooding 1517.* Tinajas Alas Pass, *Reeves 5397* (ASU). Coyote Water, *Felger 98-119.* Camino del Diablo, SE of Raven Butte, 25 Oct 2004, *Felger* (observation). †Butler Mts, seed/fruit, 11,060 ybp.

Mirabilis tenuiloba S. Watson. Long-lobed four o'clock

Herbaceous perennials; exceptionally sticky with glandular-pubescence. Leaves semi-succulent. Flowers white.

Canyons in Tinajas Altas Mountains. The only other known locality for this species in Arizona is in the Kofa Mountains. The plants differ from *M. laevis* in being more robust, and generally having larger, thicker, and more yellowish leaves, and larger involucres with longer lobes.

Borrego Canyon, common in canyon bottom, *Felger 92-613.* Surveyors Canyon, *Felger 10-200.* Frontera Canyon, *Felger 98-108.* Tinajas Altas Mts, *Gooding 07 Mar 1940* (ASU). Yuma Co: Palm Canyon, ca. ¾ way to the top, 8 Oct 1977, *Harrison 11* (ASU).

ONAGRACEAE—Evening-Primrose Family

All members of this family in the flora area grow and flower during the cool seasons, and the flowers are vespertine (opening near sunset) and collapse after sunrise depending on temperature.

1. Petals (2) 2.5–6 cm long, uniformly (monochromatic) yellow or white without spots or other markings **Oenothera**

1. Petals 0.2–1.7 cm long, color various, often with spots or other markings (*Camissonia* sensu lato).

  2. Flowers and capsules pedicelled **Chylismia**

  2. Flowers and capsules sessile (caution: the slender ovary base may appear like a pedicel).

    3. Flowers minute, petals 2–2.5 mm long, whitish or pink **Eremothera**

    3. Flowers small but not minute, petals 5–7.5 mm long, bright yellow or orange **Eulobus**

CHYLISMIA

1. Largest leaves on stems well above base of plant, leaves not in a basal rosette; leaf blades about wide as long, rounded to ovate or somewhat triangular, toothed or serrated **C. arenaria**

1. Largest leaves in a basal rosette, stem leaves reduced; leaf blades more than 3 times longer than wide, the leaves pinnately lobed to divided **C. claviformis**

Chylismia arenaria A. Nelson [*Camissonia arenaria* (A. Nelson) P.H. Raven] Desert suncup

Annuals to short-lived perennials. Flowers yellow, becoming pink with age.

Rocky slopes and canyons in the Tinajas Altas Mountains.

Tinajas Altas, *Harrison 3608*. Canyon above Tinajas Altas, *Felger 04-83*.

Chylismia claviformis (Torr. & Frém.) A. Heller subsp. **peeblesii** (Munz) W.L. Wagner & Hoch [*Camissonia claviformis* (Torr. & Frém.) P.H. Raven subsp. *peeblesii* (Munz) P.H. Raven] BROWNEYES

Annuals. Flowers white, sometimes with pink tinges, and with a red-brown center, the flowers becoming pink with age and often purplish when dry; the stamens, style, and stigma white.

Widespread, especially on sandy to gravelly soils; washes, valley plains and bajadas, canyons, and rocky slopes.

Tinajas Altas, *Van Devender 5 Mar 1983*. Canyon below Raven Butte Tank, *Felger 10-222*. Tinajas Altas Pass, *McLaughlin 1973*.

Eremothera chamaenerioides (A. Gray) W.L. Wagner & Hoch [*Camissonia chamaenerioides* (A. Gray) P.H. Raven] WILLOW-HERB EVENING-PRIMROSE

Annuals. Flowers very small, at first white, often becoming pink with age; opening near sunset, usually collapsing soon after sunrise. This is the smallest-flowered evening primrose in the Sonoran Desert; the floral structure and modifications are characteristic of self-pollinated flowers.

Widespread, especially on rocky slopes from low to high elevations.

Tinajas Altas, rocky slope, 1900 ft, *Van Devender 5 Mar 1983*. Tinajas Altas, *Goodding 6 Mar 1940* (ASU). Surveyors Canyon, canyon bottom, *Felger 10-211*. Above the tinajas, 19 Mar 1998, *Felger* (observation).

Eulobus californicus Nutt. ex Torr. & A. Gray [*Camissonia californica* (Nutt. ex Torr. & A. Gray) P.H. Raven. *Oenothera leptocarpa* Greene] CALIFORNIA SUNCUP

Annuals; plants erect and often sparsely branched, the leaves usually shed by the time of flowering. Flowers yellow, becoming orange with age and often drying pink.

Widespread across the flora area; washes, plains, bajadas, canyons, and rocky slopes.

Tinajas Altas, *Van Devender 05 Mar 1983*. Tinajas Altas Canyon, above the tinajas, 19 Mar 1998, *Felger* (observation). Surveyors Canyon, canyon bottom, *Felger 10-206*. Vicinity of Coyote Water, *Felger 04-34*.

Oenothera primiveris A. Gray. YELLOW DESERT EVENING-PRIMROSE

Annuals. Flowers relatively large and lemon-yellow. Capsules woody, persisting on the dried stems long after the plants perishes.

Sandy gravel or silty-clayish soils of washes, sand flats, canyons, and sometimes in soil pockets on rocky slopes. Specimens in the region are generally identifiable as subsp. *bufonis* (M.E. Jones) Munz, distinguished by larger and generally cross-pollinated flowers.

Coyote Water, *Felger 04-54*. Canyon below lowermost Tinajas Altas, 19 Mar 1998, *Felger* (observation).

OROBANCHACEAE—BROOMRAPE FAMILY

†CASTILLEJA sp./spp.

There are records for the genus dated at 11 millennia in the flora area and 20.5 millennia in the Ajo Mountains in Organ Pipe Monument. The nearest present-day members are *C. exserta* (A. Heller) T.I. Chuang & Heckard subsp. *exserta* (owl's clover) at Jose Juan Charco in Cabeza Prieta Refuge and *C. lanata* A. Gray (Indian paintbrush) in the Ajo Mountains.

†Tinajas Altas, seeds, 11,040 ybp. Ajo Mountains, 20,490 ybp.

Orobanche cooperi (A. Gray) A. Heller. DESERT BROOMRAPE; MO'OTADK

Apparently annuals; parasitic on roots of *Ambrosia* shrubs including *A. dumosa* and sometimes *A. ilicifolia* and *A. salsola*, and also reported on *Larrea* (Wiggins 1964). Stems very thick and succulent, appearing in spring, flowering and withering by the end of April or sooner. Flowers purple and white, and the throat marked with yellow.

Often locally common on sandy flats and bajadas, sandy-gravelly washes, and canyon bottoms. Widespread across the flora region. The young plants are edible after thorough roasting.

Near jct of Camino del Diablo and Cipriano Pass Road, Tinajas Altas Mts, *Van Devender 6 Mar 1983*. Frontera Canyon, *Felger 98-104*. Camino del Diablo (West Rte), Davis Plain W of Tinajas Altas Mts, *Reeves R5427* (ASU).

PAPAVERACEAE—POPPY FAMILY

Eschscholzia minutiflora S. Watson. LITTLE GOLD-POPPY

Cool-season annuals. Flowers small and yellow.

Seasonally common during years of favorable rains in the Tinajas Altas Mountains; washes and at least the lower slopes. Like so many other species of ephemerals in the more arid regions of the Sonoran Desert, this poppy is not seen during dry years. In spring 1983 Tom reported it as being rare, and Richard did not record it in the flora area until his spring 2010 field trip, when it was widespread and common.

Vicinity of Tinajas Altas, rare, under *Larrea*, *Van Devender 5 Mar 1983*. Tinajas Altas, canyon-wash just E of the tinajas, *Felger 10-188*. Surveyors Canyon, canyon bottom, *Felger 10-206*.

PLANTAGINACEAE (Includes Scrophulariaceae in part)—Plantain Family

1. Vegetative stems short or not developed; flowers 4-merous, the corollas whitish or brown; flowers and fruits sessile; seeds smooth, 2 per capsule **Plantago**
1. Vegetative stems well developed and leafy; flowers 5-merous, the corollas rose-pink or purple; seeds rough-surfaced, many per capsule.
    2. Herbage viscid-sticky; stems usually less than 25 cm long; lowermost leaves paired, others alternate, leaves ovate to broadly lanceolate, prominently petioled; corollas purple **Pseudorontium**
    2. Herbage not viscid sticky; stems usually more than 30 cm long; leaves opposite; corollas rose-pink **Penstemon**

PENSTEMON—Beard tongue

Generally herbaceous perennials, probably short-lived, also flowering in first season.

1. Leaf margins entire, all leaves separate (not connate) **P. parryi**
1. Leaf margins toothed, the upper leaves joined at base (connate) **P. pseudospectabilis**

Penstemon parryi (A. Gray) A. Gray. Desert penstemon; *jaritos, varita de San José*; hevel 'e'es

Usually perennials but at least sometimes functioning as cool-season annuals. Leaves moderately glaucous. Flowers rose-pink, February to April.

Known from the flora area by a single plant and therefore not collected; it was not a perennial.

Tinajas Altas, wash just below the lower tank, rare, 10 Jan 2002, *Felger* (observation).

Penstemon pseudospectabilis M.E. Jones var. **pseudospectabilis.** Mojave beard-tongue

Herbaceous perennials, also flowering in the first year. Flowers bright rose-purple; observed in flower February to May.

Canyons and at higher elevations in the mountains, generally not common.

Tinajas Altas, frequent in wash above tanks, 487 m, *Hodgson 2723* (DES). Canyon above Tinajas Altas, canyon bottom and lower N-facing slopes among rocks, *Felger 04-77*. Frontera Canyon, 18 Mar 1998, *Felger* (observation).

†**Penstemon** sp.

†Tinajas Altas, fruits, 10,950 & 11,040 ybp.

Plantago ovata Forssk. var. **fastigiata** (E. Morris) S.C. Meyers & Liston [*P. insularis* Eastw. Not *P. insularis* Nyman ex Briq. *P. fastigiata* E. Morris. *P. insularis* var. *fastigiata* (E. Morris) Jeps.] Desert woolly plantain, Indian wheat; *pastora*; mumsa

Cool-season annuals; highly variable in size, flowering stems often 5–20 cm tall. Flowers small, straw-colored and papery. Seeds mucilaginous when wet and clinging tenaciously when dry.

Abundant and widespread, especially on sandy soils; washes, valley plains and bajadas, canyons, and soil pockets on rocky slopes. The seeds were significant food and medicinal resources. It has been in the flora area for more than 11,300 years and in Organ Pipe Monument for more than 20,500 years. Van Devender et al. (1990a) reported 10,000-year-old fossils from the Hornaday Mountains in the Pinacate region.

Drought-stressed plants can be as small 6.4–12 mm tall, with persistent cotyledons to 12 mm long, only 2 leaves, each 7 mm long, and a peduncle bearing a single fruit.

The present-day population is the inland North American variety (Meyers & Liston 2008). The infraspecific status of the fossils is not known.

Coyote Water, *Felger 05-123*. Cipriano Pass, *Reeves R5448* (ASU). Tinajas Altas, *Felger 10-193*. Observations: Canyon above Tinajas Altas, 19 Mar 1998, *Felger*; Frontera Canyon, 18 Nov 1998, *Felger*. †Butler Mts, seeds, 740–11,250 ybp (6 samples). †Organ Pipe Monument: Ajo Mts, Montezuma's Head, seeds, 20,490 ybp.

Pseudorontium cyathiferum (Benth.) Rothm. [*Antirrhinum cyathiferum* Benth.] Desert snapdragon

Non-seasonal annuals, viscid glandular-hairy (sticky) and foul smelling. Flowers small and dark purple.

Known in the flora area from a single locality but probably more widespread.

Among rocks in the bottom of Frontera Canyon, 18 Mar 1998, *Felger* (observation).

POLEMONIACEAE—Phlox Family

All members of this family in the flora area are cool-season annuals.

1. Leaves opposite (upper leaves sometimes alternate); flowers nocturnal, pure white _____ **Linanthus**
1. Leaves alternate; flowers diurnal, blue, pink, or white tinged with violet.
  2. Flowers in woolly heads; flowers blue _____ **Eriastrum**
  2. Flowers not in woolly heads; flowers not blue.
    3. Leaves and calyx lobes bristle-tipped; flowers sessile in leaf axils or in dense, compact and leafy-bracted heads.
      4. Leaves broadest near the tip; most leaves with some 2- or 3-forked bristles; corollas radial or nearly so _____ **Langloisia**
      4. Leaves linear, not expanded above; leaf bristles all single; corollas bilateral, 2-lipped _____ **Loeseliastrum**
    3. Leaves and calyx lobes not bristle-tipped; flowers mostly pedicelled, in open inflorescence overtopping the leaves.
      5. Leaves more or less ovate, toothed but not dissected, to about 2 times longer than wide; flowers pink _____ **Aliciella**
      5. Leaves pinnately dissected, more than 3 times longer than wide; flowers white tinged with violet _____ **Gilia**

Aliciella latifolia (S. Watson) J.M. Porter subsp. **latifolia** [*Gilia latifolia* S. Watson] Broad-leaf gilia

Plants highly variable in size; flowers pink.

Known for certain from a single record from near the northern margin of the flora area.

Pass N of Tinajas Altas Pass, 1200 ft, *Halse 31 Mar 1973.*

Eriastrum diffusum (A. Gray) H. Mason. Woolly-star

Flowers small and blue, the corollas tend to fall with daytime heat. The small flowers and small anthers point to a selfing (autogamous) habit.

Washes, bajadas, and low hills.

NE end of Tinajas Altas Pass, *Van Devender 6 Mar 1983.* Coyote Water, 18 Mar 1998, *Felger* (observation).

Gilia stellata A. Heller. Star gilia

Basal rosette leaves well developed, stem leaves greatly reduced. Flowers white tinged with violet.

Common and widespread across the flora area; washes, bajadas, hills, and mountains.

Tinajas Altas Pass, *Van Devender 5 Mar 1983.* Tinajas Altas, *Felger 10-189.* Coyote Water, *Felger 05-146.*

Langloisia setosissima (Torr. & A. Gray) Greene subsp. **setosissima.** Bristly langloisia

Plants bristly and compact, 2–5 cm tall. Corollas bright lavender-pink; anthers and pollen white or blue.

Sandy to rocky soils; washes, valley plains and bajadas, hills, and mountains.

E side Tinajas Altas Pass, *Felger 98-102.*

Linanthus jonesii (A. Gray) Greene. Jones' desert-turmpet

Stems wire-like, the plants usually taller than broad. This species charactrized by simple leaves, very coarse glandular hairs (the glands are large, multicellular structures), and relatively small fruit. Flowers white, nocturnal, opening shortly after dusk and powerfully sweet-fragrant, sometimes nauseously sweet, and closing before sunrise.

Washes, valley plains and bajadas, canyons, hills, and mountains at least at lower elevations.

Tinajas Altas, *Van Devender 26 Mar 1983* (det. J. Mark Porter 2012). Frontera Canyon, 18 Mar 1998, Felger (observation, presumably the same species).

Loeseliastrum schottii (Torr.) Timbrook [*Langloisia schottii* (Torr.) Greene] Schott's calico

Plants with a short main axis and compact to spreading branches. Flowers white or pink and showy.

Low dunes near the west side of Tinajas Altas Mountains and perhaps elsewhere in the western part of the flora area.

Butler Mts, *Van Devender 27 Mar 1983.*

POLYGONACEAE—Buckwheat Family

1. Small shrubs _____ **Eriogonum**
1. Annuals or herbaceous perennials.
  2. Small annuals; involucres single-flowered, bearing spine-tipped teeth _____ **Chorizanthe**
  2. Annuals or herbaceous perennials; involucres multiple flowered with blunt-tipped teeth or bracts.
    3. Annuals or herbaceous perennials, with or without woolly hairs; leaf blades about as wide as long _____ **Eriogonum**
    3. Annuals with woolly hairs; leaf blades several times longer than wide _____ **Nemacaulis**

CHORIZANTHE—Spine-flower

Small spring annuals; first leaves in a basal rosette; flowers minute, white or yellow and barely protruding or hidden in firm, spinescent bracts. The larger leaves in a basal rosette, soon deciduous, usually withering by early March. Flowering mostly February to March, the plants mostly mature in April. By the time they are in full flower with onset of fruiting, the weather is warm and the plants are leafless or nearly so.

1. Stems slender and not spiny, the stems and inflorescences fragile and breaking apart at maturity ______ **C. brevicornu**
1. Stems stout and spiny, not breaking apart at maturity, the died plants ("skeletons") tough and persistent ______ **C. rigida**

Chorizanthe brevicornu Torr. subsp. **brevicornu.** Brittle spineflower, short-horn spineflower

Cool-season annuals. Flowers white and minute. As the plants mature and dry in April and early May, they completely break apart, the inflorescence branches breaking into small seed-bearing segments that have tiny grappling-hook spines at the nodes that aid in dispersal.

Sandy, gravelly, and rocky soils; washes, canyons, upper bajadas, pediments, and lower mountain slopes. It was in the flora area 10,400 years ago.

Tinajas Altas, *Van Devender 5 Mar 1983*. Steep canyon slope N of Tinajas Altas, 19 Mar 1998, *Felger* (observation). †Butler Mts, fruit-bearing segments (with hooks), 10,360 ybp.

Chorizanthe rigida (Torr.) Torr. & A. Gray. Devil's spineflower; *tapacola*

Cool-season annuals. Flowers yellow-green, minute and barely visible. Plants drying as a rigid, spinescent skeleton resembling a miniature ocotillo and often persisting for a number of years.

Widespread; bajadas and valley plains, washes, pediments, and lower rocky slopes. It has been in the flora for at least 8200 years.

Camino del Diablo SE of Raven Butte, *Felger 05-33*. NNE of parking area at Tinajas Altas, *Felger 10-216*. Granitic hills at SW side of Tinajas Altas Mts, 10 Jan 2002, *Felger*, observation. †Butler Mts, 3-parted floral bracts, 740–8160 ybp (3 samples).

ERIOGONUM—Wild buckwheat

Small annuals to woody shrubs ranging across the entire region. This is one of the more diverse genera in the flora area in terms of number of species (6) as well diversity in growth forms.

1. Small shrubs; stems leafy (although leaves drought deciduous and often reduced).
  2. Involucres (flowers) in dense, head-like clusters on top of well-developed peduncles; involucres ca. 2.5 mm long ______ **E. fasciculatum**
  2. Involucres solitary and sessile at nodes (flowering branches may appear racemose); involucres 1–1.7 mm long ______ **E. wrightii**
1. Annuals or herbaceous perennials; stems not leafy, the leaves at the base of the plant and often forming a basal rosette.
  3. Annuals and perennials; leaves green, hairy but not woolly; major flowering stems not unusually slender, not thread-like.
    4. Perennials and forming a hard, knotty base and also flowering in first year; involucres 5-lobed; tepals (1.5–)2–2.7 (–3.5) mm long ______ **E. inflatum**
    4. Annuals; involucres 4-lobed, tepals 1.2–1.8 mm long ______ **E. trichopes**
  3. Annuals; leaves grayish green, woolly at least below; flowering branches very slender, thread-like.
    5. Flowering branches and involucres glabrous; involucres 0.8–2.3 mm long; outer tepals longer than wide, broadest and swollen (inflated) at base ______ **E. thomasii**
    5. Flowering branches and involucres glandular pubescent; involucres 2–3.2 mm long; outer tepals as wide as or wider than long, broadest above (towards the tip), narrowed at base to a claw ______ **E. thurberi**

Eriogonum fasciculatum Benth. var. **polifolium** (Benth.) Torr. & A. Gray. Flat-top buckwheat

Small shrubs; flowers whitish or pink; February to May.

Upper bajadas and washes, canyons, and rocky slopes in the mountains, especially at higher elevations in canyons and east- and north-facing rocky slopes. The history of this variety in the flora area extends to 11,100 years, and this species has been in the area at least 18,700 years.

Tinajas Altas, *Shreve 5942*. Tinajas Altas Mts, NE of upper tanks, *Felger 04-74*. †Butler Mts, leaves, 8160–11,060 ybp (3 samples). †Variety unknown: Tinajas Altas, leaves, 5080–18,700 ybp (7 samples).

Eriogonum inflatum Torr. & Frém. Desert trumpet, bladder stem

Perennial herbs with a hard, knotty base; leaves basal, the flowering stems leafless, the first internode erect or nearly so, the upper part inflated (swollen and hollow) or not without apparent pattern. Flowers small and yellow, mostly in spring and again with the summer rains.

Canyons, rocky hills and mountain slopes. It grew in the Butler Mountains 8200 years ago.

Canyon below Raven Butte Tank, *Felger 10-226.* Cipriano Pass, N end of Tinajas Altas Mts, *Reeves 5441* (ASU). Observations: Canyon above Tinajas Altas, 19 Mar 1998, *Felger*; Granitic hills at SW side of Tinajas Altas range, 10 Jan 2002, *Felger.* †Butler Mts, fruit with calyx, 8160 ybp.

Eriogonum thomasii Torr. THOMAS' WILD BUCKWHEAT

Small, delicate, cool-season annuals. Flowers pink and yellow; flowering branches and involucres glabrous, the outer tepals longer than wide, and broadest and swollen at base.

Washes, valley plains and bajadas, and canyons.

Coyote Water, *Felger 05-153.* Vicinity of Tinajas Altas, 1900 ft, *Van Devender 5 Mar 1983.* Canyon below Raven Butte Tank, *Felger 10-227.*

Eriogonum thurberi Torr. THURBER'S WILD BUCKWHEAT

Small, delicate, cool-season annuals. Flowers white or pink; flowering branches and involucres glandular pubescent; outer tepals as wide or wider than long, broadest towards the tip, and narrowed to a claw at the base.

Sandy soils on west side of the Tinajas Altas Mountains.

E edge of Davis Plain, west branch of Camino del Diablo, *Felger 05-93.*

Eriogonum trichopes Torr. LITTLE DESERT TRUMPET

Cool-season annuals; highly variable in size. Flowers yellow.

Sandy, gravelly soils; valley plains, bajadas, and washes.

Camino del Diablo, SE of Raven Butte, *Felger 05-28.* Coyote Wash at Camino del Diablo, 10 Jan 2002, *Felger* (observation).

Eriogonum wrightii Torr. ex Benth. var. **nodosum** (Small) Reveal [*E. wrightii* var. *pringlei* (J.M. Coult. & Fisher) Reveal] BASTARD SAGE

Small, scruffy subshrubs with whitish stems and small, quickly drought-deciduous leaves. Flowers white or pink; flowering response apparently non-seasonal, or perhaps not during summer.

Mountains, especially north-facing slopes and canyons. This species has been in the flora area for more than 43,000 years.

Tinajas Altas, 5 Dec 1935, *Goodding 1449.* Frontera Canyon, 18 Mar 1998, *Felger* (observation). †Variety unknown: Tinajas Altas, leaves, 5860–15,680 (14 samples), & >43,000 ybp.

Nemacaulis denudata Nutt. var. **gracilis** Goodman & L.D. Benson. WOOLLY HEADS

Cool-season annuals with very slender, delicate, and spreading stems. Flowers minute, yellow, surrounded by yellow-green or white and pink woolly bracts.

Dunes and sand flats west of the Tinajas Altas Mountains.

Butler Mts, *Van Devender 27 Mar 1983.*

PORTULACACEAE—PURSLANE FAMILY

Portulaca halimoides L. [*P. parvula* A. Gray] SILK-COTTON PURSLANE

Summer annuals, the plants small and succulent. Sepals reddish and relatively persistent; petals, anthers, and stigma golden yellow but these are only evident while the flowers are open—generally from a few hours after sunrise until late morning or mid-day.

Sometimes seasonally common along Coyote Wash.

Coyote Water, *Felger 04-61.*

RANUNCULACEAE—RANUNCULUS FAMILY

†**Anemone tuberosa** Rydb. DESERT WINDFLOWER

Small, herbaceous root perennials; growing and flowering in spring.

It was at Tinajas Altas nearly 10,000 years ago. The nearest present-day population occurs in Arizona Upland in the Ajo Mountains, especially at higher elevations. It is generally not known from the Lower Colorado Desert region, with the exception of a few records from the Whipple Mountains (De Groot 2007).

†Tinajas Altas, seeds, 9900 ybp.

RESEDACEAE—MIGNONETTE FAMILY

Oligomeris linifolia (Vahl) J.F. Macbr. DESERT CAMBESS

Annuals, recorded in the region from October through May. Flowers minute and inconspicuous, white and green.

Usually localized; sandy to rocky soils, valley plains, washes, canyons, and bajadas.

Butler Mts, *Van Devender 27 Mar 1983.* Coyote Water, *Felger 04-53.*

RHAMNACEAE—Buckthorn Family

†**Condalia** cf. **globosa** I.M. Johnst. Crucillo

Hardwood shrubs or small trees with small leaves. Fruits small drupes with a thin blackish pulp.

It is documented from Tinajas Altas between 9000 and 11,000 years ago. The nearest present-day population of *C. globosa* is in the northeastern part of Cabeza Prieta Refuge, where it grows in large arroyos and canyons, and the east side of the Pinacate region.

†Tinajas Altas, seeds, 8970 & 10,950 ybp.

Ziziphus obtusifolia (Hook. ex Torr. & A. Gray) A. Gray var. **canescens** (A. Gray) M.C. Johnst. [*Condalia lycioides* (A. Gray) Weberb. var. *canescens* (A. Gray) Trel.] White crucillo, graythorn; *abrojo*; ʼu:spad, ʼus jevedpad

Sprawling hardwood shrubs 2–3 m tall, with rigid branches, forming dense, thorny tangles. Leaves mostly 8–20 mm long, often grayish green, quickly drought deciduous, with sparse foliage, the shrubs often nearly leafless. Flowers small, yellow-green, appearing at least in early summer. Fruits ca. 1 cm long, edible and slightly sweet but hardly worth the bother.

Uncommon and widely scattered in washes, canyon bottoms, upper bajadas, and lower slopes along the east side of the Tinajas Altas Mountains, and more common at the south end of Coyote Wash. It has been at Tinajas Altas for at least 8700 years.

Tinajas Altas, wash just E of the tinajas, *Felger 08-170.* Camino del Diablo at Coyote Wash, 10 Jan 2002, *Felger* (observation). †Tinajas Altas, twigs, 1230–8700 ybp (3 samples).

Galium stellatum Kellogg [*G. stellatum* var. *eremicum* Hilend & J.T. Howell] Starry bedstraw

Untidy small shrubs or subshrubs. Stems brittle, square in cross-section with stringy, peeling bark. Leaves small and sharp pointed. Flowers minute, whitish or pale yellow, in spring.

Widespread in the Tinajas Altas Mountains, especially on north- and east-facing slopes and in canyons. It has been in these mountains for more than 18,700 years.

Tinajas Altas, *Harrison & Kearney 6574.* 1 mi N of Tinajas Altas, *Kurtz 1153.* Surveyors Canyon, canyon bottom, *Felger 10-209.* Frontera Canyon, 18 Mar 1998, *Felger* (observation). †Tinajas Altas, stems, leaves, fruits, 4010–18,700 ybp (13 samples).

RUSCACEAE, see ASPARAGACEAE

RUTACEAE—Rue or Citrus Family

Thamnosma montana Torr. & Frém. Turpentine broom

Small, gland-dotted shrubs; stems yellow-green; herbage and flowers highly aromatic, the new growth,with a lemon-like fragrance when crushed; stems yellowish green. Foliage sparse, the leaves reduced above to scales and very quickly shed. Flowers ca. 1 cm long, dark indigo-blue. Flowering and fruiting January to April. Flowers stinking at mid-day, visited by large syrphid flies and honeybees (the bees vigorously stick their heads all the way into the corolla, spreading apart the petals to get inside).

Hot, exposed rocky hills, slopes and ridges in the Tinajas Altas Mountains. It has been in these mountains for more than 43,000 years.

Tinajas Altas Mts, *Harrison 3612.* SE base of Tinajas Altas Mts, *Felger 98-103.* Tinajas Altas Canyon, *Felger 08-178.* †Tinajas Altas, twigs, fruits, 5080–15,050 (4 samples), & >43,000 ybp.

SANTALACEAE—Sandalwood Family (includes Viscaceae)

Phoradendron californicum Nutt. Desert mistletoe; *toji*; ha:kvad

Epiphytic parasites; stems photosynthetic and with scale leaves. Male and females flowers on separate plants; flowers small, green or yellow, highly fragrant and attracting great numbers of insects; flowering and fruiting at various seasons, with mass flowering often December to February and fruits ripening in late winter to early spring. The translucent white or whitish and pale orange fruits are a major food of phainopeplas.

Parasitic on the larger woody legumes, *Olneya, Parkinsonia, Prosopis, Senegalia,* and rarely on *Larrea* and *Asclepias albicans.* Distributed with the hosts. Desert mistletoe has been in the flora area for at least 8200 years.

Coyote Water, on *Prosopis glandulosa*, *Felger 04-59.* Observations: Camino del Diablo near Coyote Wash, on *Asclepias albicans*, 29 Dec 2001, *Felger*; Tinajas Altas, on *Olneya*, 19 Mar 1998, *Felger.* †Butler Mts, fruits, 740–8160 ybp (3 samples).

SCROPHULARIACEAE, see **OROBANCHACEAE** and **PLANTAGINACEAE**

SOLANACEAE—Nightshade Or Potato Family

Annuals or perennials including woody shrubs. Flowers 5-merous, radially symmetrical, the corollas sympetalous.

1. Hardwood shrubs with spines or thorn-tipped twigs **Lycium**
1. Unarmed herbaceous annuals or herbaceous perennials sometimes scarcely woody at the base.
  2. Plants stinky; corollas 8–17 cm long; fruits spinescent **Datura**
  2. Plants not stinky; corollas less than 3 cm long; fruits not spinescent.
    3. Corollas white or cream-white; fruiting calyx not enlarging; fruit a capsule (dry) **Nicotiana**
    3. Corollas yellow or yellowish; fruiting calyx enlarging to partially or fully surround fruit; fruit a berry (fleshy).
      4. Fruiting calyx partially growing around and tightly enclosing the berry; corollas tomentose between the stamen bases (resembling a woolly pad in the center) **Chamaesaracha**
      4. Fruiting calyx loosely growing around the berry like a paper bag; corollas not tomentose **Physalis**

Chamaesaracha coronopus (Dunal) A. Gray. False nightshade

Herbaceous perennials from deeply buried roots, the stems often partially buried. Flowers cream-yellow, various seasons including spring and late summer. The above-ground portion is frost-sensitive.

Locally common along Coyote Wash.

Coyote Water, *Felger 04-35.* Coyote Wash at Camino del Diablo, *Felger 04-63.*

Datura discolor Bernh. Desert datura; *toloache*

Non-seasonal annuals but frost sensitive and responding poorly to cooler weather; highly variable in size—ca. 10 cm to occasionally 1 m tall. Herbage stinky. Flowers usually 8–17 cm long, white with a purple flush in the throat, nocturnal and fragrant. Fruits globose, spiny capsules, turning down at maturity.

Widely scattered across the flora area; washes, bajadas and valley plains, and canyon bottoms. The flowers are the largest of any plant in the region, but are comparatively small within the genus.

Camino del Diablo, SE of Raven Butte, *Felger 04-20.* Coyote Wash at Camino del Diablo, *Felger 04-64.* Observations: Tinajas Altas, bajada, 19 Mar 1998, *Felger*; Frontera Canyon, 18 Mar 1998, *Felger.*

LYCIUM—Wolfberry; *salicieso*

The four species in the region are hardwood shrubs often 1–2 m tall and armed with spines or thorn-tipped twigs. Leaves semi-succulent, the margins entire.

Lycium fremontii is morphologically gynodioecious: different plants have (1) smaller flowers that are male-sterile, with well-developed female parts and reduced or sterile stamens and anthers—these plants produce fruit, or (2) larger flowers that appear bisexual with well-developed male and female parts, however, these plants may be largely or functionally male and have substantially reduced or no fruit production (Miller & Venable 2002). The other three species in the flora area produce bisexual flowers. The fruits are edible (except *L. macrodon*), although only *L. fremontii* seems to have been a significant food plant (Felger 2007; Felger & Moser 1985; Hodgson 2001).

1. Stems with spines at nodes; corollas white and green; fruits hard and greenish glaucous, 1- or 2-seeded **L. macrodon**
1. Stems often thorn-tipped, the nodes without spines; corollas white or lavender; fruits fleshy, orange to red-orange when ripe, several- to many-seeded.
  2. Calyx lobes about as long as, or longer than the calyx tube (lobes sometimes shorter on some flowers on a shrub, but some longer-lobed calyces usually present) **L. parishii**
  2. Calyx lobes shorter than the tube.
    3. Plants glabrous; pedicels mostly 1–7 mm long; flowers bisexual, slender, the corolla tube narrow and cylindrical or nearly so **L. andersonii**
    3. Leaves, pedicels, and calyces glandular-pubescent; pedicels 4–16 mm long; male and female flowers on different plants, the female flowers smaller than the male flowers; corolla tubes not narrow and cylindrical **L. fremontii**

Lycium andersonii A. Gray var. **andersonii** [*L. andersonii* var. *deserticola* (C.L. Hitchc.) Jeps.] Anderson's wolfberry

Spinescent shrubs to 2+ m tall. Leaves slender and glabrous. Flowers small, slender, and lavender; non-seasonal. Fruits orange, fleshy, and edible.

Canyons and washes along the east side of the Tinajas Altas Mountains (**Fig. 15**).

Arroyo 2 mi SE of Tinajas Altas, *Felger 08-196*. Borrego Canyon, 3 Feb 1990, *Felger* (observation).

Lycium fremontii A. Gray var. **fremontii.** Frémont wolfberry; *salicieso*; kuavulī

Readily recognized by the glandular hairs on the herbage, pedicels, and calyx; long pedicels; dimorphic flowers (male and female flowers on separate plants); and relatively large, soft, red-orange, fleshy, and edible fruits. Flowers lavender. The wet foliage smells like a wet dog.

Widely scattered and often locally common along washes.

Coyote Water, *Felger 04-48*. Arroyo 2 mi SE of Tinajas Altas, *Felger 08-197*. Below Tinajas Altas, wash, *McLaughlin 1967*. Camino del Diablo, E of Raven Butte, 29 Nov 2001, *Felger* (observation).

Lycium macrodon A. Gray. Desert wolfberry; s-cuk kuavulī

Long-shoot nodes often bearing stout spines; leaves often moderately glaucous and sometimes unusually large on long shoots. Flowers white and green, February to April. Fruits hard, glaucous, and constricted (appearing pinched) below the middle.

Washes, sand flats, alluvial flats, and sometimes on north-facing slopes at lower elevations. It grew in the Butler Mountains 8200 years ago but is not found there today. The fossil fruits are hard and bony.

Base of Tinajas Altas Mts, *Harrison & Kearney 6571*. Tinajas Altas, Gila Mountains, 6 Mar 1937, *Harbison 16816*. Camino del Diablo at Coyote Wash, *Felger 10-164*. †Butler Mts, twigs, leaves, fruits, 8160 ybp.

Lycium parishii A. Gray. Parish wolfberry; *salicieso*

Readily recognized by the markedly glandular-pubescent herbage, pedicels, and sepals, pale gray-green foliage, and pale lavender flowers with highly variable calyx lobes often much longer than the calyx tube. Corollas lavender; flowering response non-seasonal after rains. Fruits orange, fleshy, and marginally edible.

This is the most common and widespread lycium in the flora area. Washes, flats, canyons, and rocky slopes.

Coyote Water, abundant, *Felger 04-49*. Tinajas Altas, *Van Devender 9 Mar 1980*. Tinajas Altas Pass, *Reeves R5369* (ASU). Observations: Granitic hills at SW side of Tinajas Altas range, 10 Jan 2002, *Felger*; Frontera Canyon, 18 Mar 1998, *Felger*.

†**Lycium** sp./spp.

These fossil samples may represent more than one species. These seeds are the flattish, oval, and orange-brown typical of various lycium species, but not *L. macrodon*.

†Tinajas Altas, seeds, 4010–10,950 ybp (4 samples).

NICOTIANA—Tobacco

Glandular-pubescent annual or perennial herbs; fruits of capsules with numerous minute seeds.

1. Spring annuals; leaves sessile to short-petioled, the stem leaves not clasping; flowers pure white, nocturnal ________ **N. clevelandii**
1. Perennials, sometimes flowering in the first season; leaves all sessile, the stem leaves clasping (the leaf base wraps around the stem); flowers cream-white, diurnal ________ **N. obtusifolia**

Nicotiana clevelandii A. Gray. Desert tobacco; *tabaquillo del coyote*; ban vivga

Cool-season annuals. The largest leaves in a well-developed basal rosette. Flowers white, nocturnal, closing in the morning or later depending on temperature.

Often along washes and beneath large shrubs or trees; mostly sandy to gravelly soils of washes, bajadas, and desert plains.

Tinajas Altas, *Kearney & Peebles 10913*. Coyote Water, *Felger 05-127*. Tinajas Altas Pass, *Reeves R5407* (ASU).

Nicotiana obtusifolia M. Martens & Galeotti [*N. trigonophylla* Dunal] Coyote tobacco, desert tobacco; *tobaco de coyote*; O'odham ha-vivga

Perennial herbs. Flowers cream-white, diurnal; growing and reproductive almost any time of year depending on soil moisture.

Widespread across the flora area; washes, bajadas, canyons, and rocky slopes. The leaves were smoked as tobacco.

Base of Tinajas Altas, *Harrison 6568*. Steep slope just N of uppermost Tinajas Altas, 19 Mar 1998, *Felger* (observation).

Physalis versicolor Rydb. [*P. crassifolia* Benth. var. *versicolor* (Rydb.) Waterf.] Desert ground-cherry; *tomatillo del desierto*

Perennial herbs or subshrubs, and sometimes flowering in the first season. Flowers dull yellow, at various seasons.

East side of Tinajas Altas Mountains in washes and canyons, and slopes to at least 2100 ft.

Tinajas Altas, *Goodding 4902*. Vicinity of Tinajas Altas, *Van Devender 5 March 1983*. Wash, 2 mi SE of Tinajas Altas, *Felger 08-206*. Frontera Canyon, 18 Mar 1998, *Felger* (observation).

†Physalis sp./spp.

Physalis has been a member of the local flora for more than 43,000 years. The seeds are diagnostic only to genus.

†Butler Mts, seeds, 740–11,250 ybp (5 samples). †Tinajas Altas, seeds, 1230 to > 43,000 ybp (20 samples).

†Solanum hindsianum Benth. [or possibly *S. elaeagnifolium* Cav.] HINDS NIGHTSHADE; *MALA MUJER*

Sparsely branched shrubs, variously spiny or not. Flowers showy and lavender.

The nearest present-day populations are in mountains in nearby northwestern Sonora and Organ Pipe Monument. The plants are frost sensitive and its northern limit seems to be determined by freezing weather (Felger 2000; Felger et al. 2007b).

The fossil seeds also match those of *S. elaeagnifolium*, which is not known from the present-day flora area but it is a common urban and agricultural weed in nearby regions. Both nightshade species have rather flat, lens-shaped seeds with a smooth and gray enamel-like surface, and their distinctive seeds compare well with the fossil seeds. The fossil nightshade was in Tinajas Altas 11,000 years ago and in the Ajo Mountains 20,500 years ago.

†Tinajas Altas, seeds, 10,950 ybp. †Organ Pipe Monument: Ajo Mountains, Montezuma's Head, seeds, 20,490 ybp.

URTICACEAE—NETTLE FAMILY

Parietaria hespera B.D. Hinton var. **hespera.** DESERT PELLITORY

Delicate cool-season annuals. Flowers minute and green.

Seasonally common along Coyote Wash and in the mountains, especially in protected niches among rocks and beneath spinescent shrubs.

Coyote Water, *Felger 04-55*. Tinajas Altas, *Felger 10-192*. Canyon below Raven Butte Tank, *Felger 10-236*.

VERBENACEAE—VERBENA FAMILY

†GLANDULARIA sp./spp.

Non-seasonal annuals or herbaceous perennials, present at Tinajas Altas 8700 years ago. The nearest present-day occurrences of the genus are *G. bipinnatifida* (Nutt.) Nutt. and *G. gooddingii* (Briq.) Solbrig in Organ Pipe Monument, and the latter is also in the eastern margin of Cabeza Prieta Refuge.

†Tinajas Altas, nutlets, 8660 ybp.

VISCACEAE, SEE **SANTALACEAE**

ZYGOPHYLLACEAE—CALTROP FAMILY

1. Shrubs with hardwood stems, usually 1 or more m tall; herbage strongly resinous; leaves with two fused leaflets appearing as one ____ Larrea
1. Annuals or herbaceous or scarcely woody perennials, plants less than 1 m tall; herbage not strongly resinous; leaves with 3 or more leaflets.
    2. Perennials and also flowering in first season; stipules spiny; leaflets 3 (or fewer when some or all leaflets are shed in drought); flowers lavender-pink ____ Fagonia
    2. Summer-fall annuals; plants unarmed; leaves with 6 or more leaflets; flowers yellow or yellow-orange ____ Kallstroemia

FAGONIA

Low-growing, spinescent perennials and also flowering in the first season. Leaves 3-foliolate. Flowers lavender-pink; flowering with warm weather at various seasons except during extended drought. No other genus is so wide ranging yet so closely restricted to the hot, arid deserts of the world. The seeds, which become mucilaginous when wet and adhere tenaciously upon drying, are probably a major factor in the unique and widely disjunct distributions (Bray 1898).

1. Stipules mostly slightly curved (at least some on each plant), 1.5–3 mm long ____ F. laevis
1. Stipules straight, the longer ones 5–12+ mm long ____ F. pachyacantha

Fagonia laevis Standl. [*F. californica* subsp. *laevis* (Standl.) Wiggins] **Fig. 20.**

Herbage glabrous or essentially so; spines short and moderately curved.

Rocky, arid slopes, canyons, and upper bajadas; not seen on open desert flats.

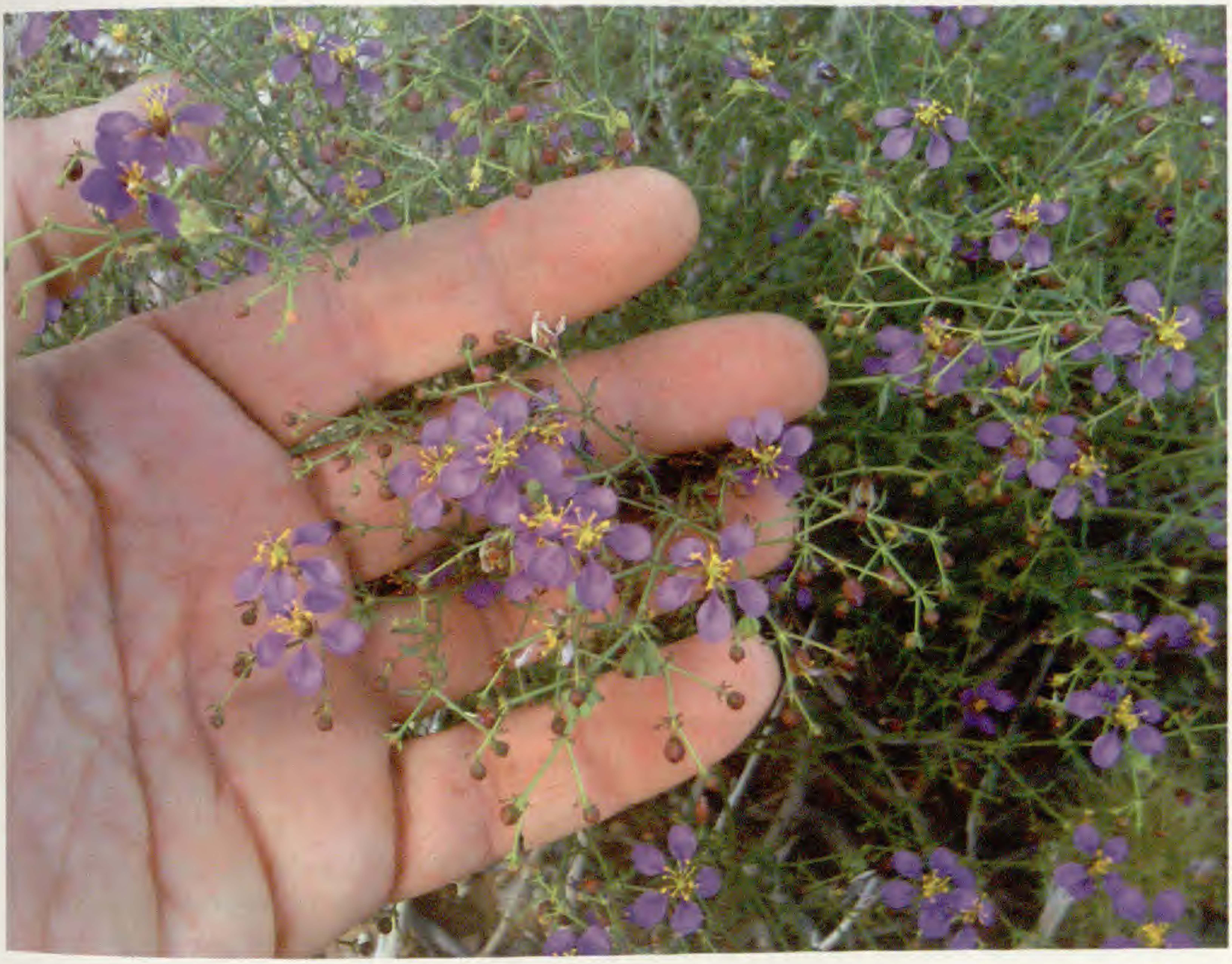

FIG. 20. *Fagonia laevis*. Tinajas Altas Canyon just above the tinajas. 28 April 2010. Photo by JM.

Borrego Canyon, *Felger 93-195*. Surveyors Canyon, *Felger 10-202*. Canyon below Raven Butte Tank, *Felger 10-230*.

Fagonia pachyacantha Rydb. [*F. californica* var. *glutinosa* Vail]

Plants glandular-pubescent; spines sharp, straight, and sometimes relatively long.

Arid, rocky slopes and canyons of hills and mountains, and upper bajadas.

Tinajas Altas Mts, 1200 ft, *Lindquist 25 Mar 1983*.

Kallstroemia californica (S. Watson) Vail. BAIBURÍN, *MAL DE OJO*

Summer annuals. Stems generally trailing; leaves pinnate. Flowers small, yellow to yellow-orange.

Documented from washes and sand flats along Coyote Wash and expected elsewhere.

Coyote Water, *Felger 04-47*.

Larrea divaricata Cav. subsp. **tridentata** (Sessé & Moc. ex DC.) Felger & C.H. Lowe [*L. tridentata* (Sessé & Moc. ex DC.) Coville] CREOSOTEBUSH; *HEDIONDILLA, GOBERNADORA*; SEGAI, SEGOI

Long-lived shrubs to 2+ m tall with very hard wood and gummy, resinous herbage. Flowers yellow, produced at various seasons except during extended drought.

Along with the common bursage *Ambrosia dumosa*, this is the most abundant and widespread shrub in the region, extending across the desert floor and on hills and mountains to at least 1570 ft. Creosotebush has been a major medicinal plant in the Sonoran Desert.

In the Sonoran Desert, *Larrea* was restricted to elevations below 1000 ft in the last glacial period (the Wisconsin) and probably many earlier glacial periods in the Pleistocene. The 18,700 ybp sample from Tinajas Altas is the oldest radiocarbon date for *Larrea* in North America. This is a tandem accelerator radiocarbon date taken directly on fossil twigs and leaves (Van Devender 1990). Kim Hunter related stomatal cell size to ploidy level, enabling her to determine that the Ice Age creosotebush from Tinajas Altas was tetraploid, demonstrating that the modern race was already here at that early date (Hunter et al. 2001). The Mojave Desert hexaploids were only found in Holocene samples—possibly formed as they migrated out of the Lower Colorado River Valley. Considering that 18,700 ybp was the Wisconsin full glacial, it is likely that creosotebush desertscrub was in the Lower Colorado Valley for much of the Pleistocene—after creosotebush immigrated from South America to the Chihuahuan Desert at some unknown previous interglacial time.

Camino del Diablo, SE of Raven Butte, *Felger 04-17.* Mesa E of Tinajas Altas, *Felger 08-187.* Canyon above Tinajas Altas, rocky bench just above arroyo bottom, 1570 ft (not seen at higher elevations), 26 Oct 2004, *Felger* (observation). †Butler Mts, twigs, leaves, fruits, 740–11,250 ybp (7 samples). †Tinajas Altas, twigs, leaves, fruits, 4010–18,700 ybp.

MONOCOTYLEDONS

1. Leaves in rosettes: thick, tough, and succulent with a stout terminal spine, or linear relatively flat and not succulent ____ **Asparagaceae** (*Agave, Nolina*)
1. Leaves not in rosettes and not as above.
  2. Herbaceous perennials from underground corms or bulbs; flowers whitish or blue and showy ____ **Asparagaceae** (*Hesperocallis, Triteleiopsis*)
  2. Annuals or perennials but not from underground bulbs; individual flowers often small, the perianth membranous or scale-like, or reduced or absent, and not petal-like.
    3. Cattails; leaves linear, erect, often to 1 m or more in length, thickened and pithy; tinaja wetland habitat ____ **Typhaceae**
    3. Grasses and sedges; leaves less than 1 m long, not thickened and pithy; widespread in many habitats.
      4. Annual sedge, stems solid (pithy); mostly 3–10 cm, each flower subtended by a single scale with a recurved awn tips; in temporarily wet soils ____ **Cyperaceae** (*Cyperus squarrosus*)
      4. Grasses; annuals or perennials; stems hollow or solid; each flower subtended by at least 2 bracts (the lemma and palea) ____ **Poaceae**

ASPARAGACEAE—ASPARAGUS FAMILY (INCLUDES AGAVACEAE, HESPEROCALLIDACEAE, NOLINACEAE, RUSCACEAE, THEMIDACEAE)

1. Century plants (agaves) and beargrasses; leaves in rosettes, firm and variously armed with spines or flexible and with razor-like finely-serrated edges.
  2. Plants stemless or the stems very short, leaves mostly less than 60 cm long, thick and succulent, not flexible, with marginal spines and a stout terminal spine ____ **Agave**
  2. Plants developing a woody trunk; leaves often about 1 m or more long, flat, not succulent, flexible, and ending in a frayed, fibrous tip (not spine-tipped) ____ **Nolina**
1. Herbaceous perennials from underground corms or bulblets (bulbs) during cooler seasons; flowers whitish or blue.
  3. Flowers on racemes; flowers white or nearly so, more than 5 cm wide or long ____ **Hesperocallis**
  3. Flowers in an umbel; flowers blue, less than 2 cm long or wide ____ **Triteleiopsis**

Agave deserti Engelm. subsp. **simplex** Gentry. DESERT AGAVE; *LECHUGUILLA, MEZCAL*; 'A'UD

Medium-sized agaves, solitary or forming small colonies from offsets. Leaves thick, dull colored, and with marginal spines. Flowers yellow, mostly April to June; fruits ripening June and July.

Widely scattered in the mountains, and occasional on upper bajadas on the eastern sides of the mountains. These agaves served as major food resources and the leaves yielded fiber.

The distribution expanded during the wetter rainfall climates of glacial times, and its range became fragmented in the Holocene. It is well represented in the fossil record from Tinajas Altas for than more than 18,700 years. Most of the fossil agave specimens were identified by Tony Burgess. His identifications were based in part on examination and comparisons of epidermal cell structure and stomatal patterns including their positions (e.g., sunken or not).

Between Camino del Diablo and Borrego Canyon, *Felger 90-19.* Tinajas Altas, *Goldman 2310* (US, image seen); *Van Devender 86-142.* †Tinajas Altas, leaf fragments (epidermis), prickles, seeds, 1230–18,700 ybp (17 samples).

Hesperocallis undulata A. Gray. AJO LILY, DESERT LILY; *AJO SILVESTRE*; A:SOS

Growing and flowering during cool seasons from a single and rather large corm ("bulb"). Flowers white, 6–8 cm wide after opening in the late afternoon or early evening, and partially closing with daytime heat of the next morning. Flowering stalks highly variable sizes, in drier years the flower stalks may scarcely be visible but in wet years they may be more than 1.5 m tall, and in the driest years the plants remain as dormant bulbs.

Mostly on deep, sandy soils of the Lechuguilla Valley, plains and bajadas, and sometimes on rocky pediments. The relatively large corms were baked or boiled and also eaten fresh, probably in spring (Castetter & Bell 1951; Felger 2007; Hodgson 2001), but are rather slimy when fresh (also see Rea 1997).

Coyote Water, *Felger 05-119.*

†**Hesperoyucca whipplei** (Torr.) Baker ex. Trel. [*Yucca whipplei* Torr. *Y. newberryi* McKelvey] SPANISH BAYONET

Agave-like rosettes more than 1 m wide, the plants dying after flowering.

This species was widespread across the Sonoran Desert in early Ice Age times (Van Devender 1990) and is documented for Tinajas Altas from 11,000 to more than 43,000 years ago. It is missing from most Sonoran Desert middle and late Holocene midden samples, indicating that the main range reduction was due to drying climatic conditions, but locally people may have had an effect (Felger 2007). In other regions this species is known to have been a significant food resource: The hearts and the young emerging flower stalks were pit-baked like those of agaves, and the flowers and seeds were also eaten (Felger 2007). The harvesting methods preclude reproduction of the plants. A small relictual population occurs in the Sierra del Viejo (immediately south of Mexico Highway 2 in adjacent Sonora south of the Tinajas Altas Mountains, a place where there is no freshwater source (Felger 2000). It is otherwise absent across most of its former range in the Sonoran Desert. Could overharvesting in early prehistoric times have contributed to the final demise of this plant across most of the Sonoran Desert?

†Tinajas Altas, leaf fragments, 11,040, 18,700, & >43,000 ybp.

Nolina bigelovii (Torr.) S. Watson. DESERT TREE-BEARGRASS, BIGELOW BEARGRASS. **Fig. 21A, B.**

Yucca-like plants developing a woody trunk and large, tall flowering stalks. Flowers small, white and green, in June, and visited by numerous insects; fruits ripening during the same season.

Canyons and slopes including crevices in cliffs and rock faces, from lowest to high elevations in the Tinajas Altas Mountains.

The young flower stalks were pit-baked by the Cahuillas (Bean & Saubel 1972). The fibrous leaves of other *Nolina* species were used for basketry and other practical uses, and the seeds prepared for food, but evidence is lacking for such use for *N. bigelovii* (Felger 2007). *Nolina bigelovii* has been in the Tinajas Altas Mountains for more than 43,000 years.

Spectacularly tall nolinas occur along the bottom of Frontera Canyon (Fig. 21A). Some of these giants have trunks 4–5 m tall, and one fallen, dead nolina had a trunk slightly more than 6 m long (measured 18 Mar 1998). Most of these giants appeared to be declining and had leaves substantially shorter than smaller, "normal-sized" plants. Scattered, few nolinas, mostly in the canyon and higher slopes above the Tinajas Altas tanks, have trunks 3–4+ m tall and may be of the same age class as the Frontera Canyon giants. Bighorn sheep eat nolina leaves (Simmons 1966).

Tinajas Altas, *Shreve 6233*. Tinajas Mts, major tinajas, 390 m, Hodgson 6975 (DES).

†Tinajas Altas, leaf fragments, 4010–18,700 (16 samples), & >43,000 ybp.

Triteleiopsis palmeri (S. Watson) Hoover [*Brodiaea palmeri* S. Watson] BLUE SAND-LILY

Growing and flowering during cooler seasons from a cluster of small cormlets (bulblets). Flowers attractive, deep blue, on tall flowering stalks.

Sand flats and dunes west of the Tinajas Altas Mountains and widespread westward to Yuma and in the nearby western part of Cabeza Prieta Refuge and the Gran Desierto in adjacent Sonora.

The cormlets are tasty, eaten fresh or cooked (Felger 2007; Felger & Moser 1985).

Butler Mts, *Van Devender 27 Mar 1983*. Near Border Monument 198, *Morrison 73* (ASU).

†**Yucca brevifolia** Engelm. var. **brevifolia** and/or var. **jaegeriana** McKelvey [*Y. jaegeriana* (McKelvey) L.W. Lenz] JOSHUA TREE

This unique tree, emblematic of the Mohave Desert, was common in Organ Pipe Monument and the flora area from at least 43,000 to about 11,000 years ago. The nearest present-day occurrences of this species are in west-central and northwestern Arizona.

†Tinajas Altas, leaf fragments, 11,040, 18,700, & >43,000 ybp (abundant in these samples).

CYPERACEAE—SEDGE FAMILY

Cyperus squarrosus L. [*C. aristatus* Rottb. *Mariscus squarrosus* (L.) C.B. Clarke] DWARF SEDGE

Diminutive non-seasonal annuals, tufted and grass-like.

Found along Coyote Wash following rains that resulted in exceptional flow through the wash. The nearest known populations are documented from Las Playas and Cabeza Prieta Tanks, and the nearby Gran Desierto in Sonora (Felger 2000). Bird-dispersal is implied since the nearest populations are not connected to Coyote Wash by surface flow.

Coyote Water, *Felger 04-41*. Cabeza Prieta Refuge: Las Playas, *Monson 9*. Cabeza Prieta Tanks, *Monson 25 Sep 1955* (CAB).

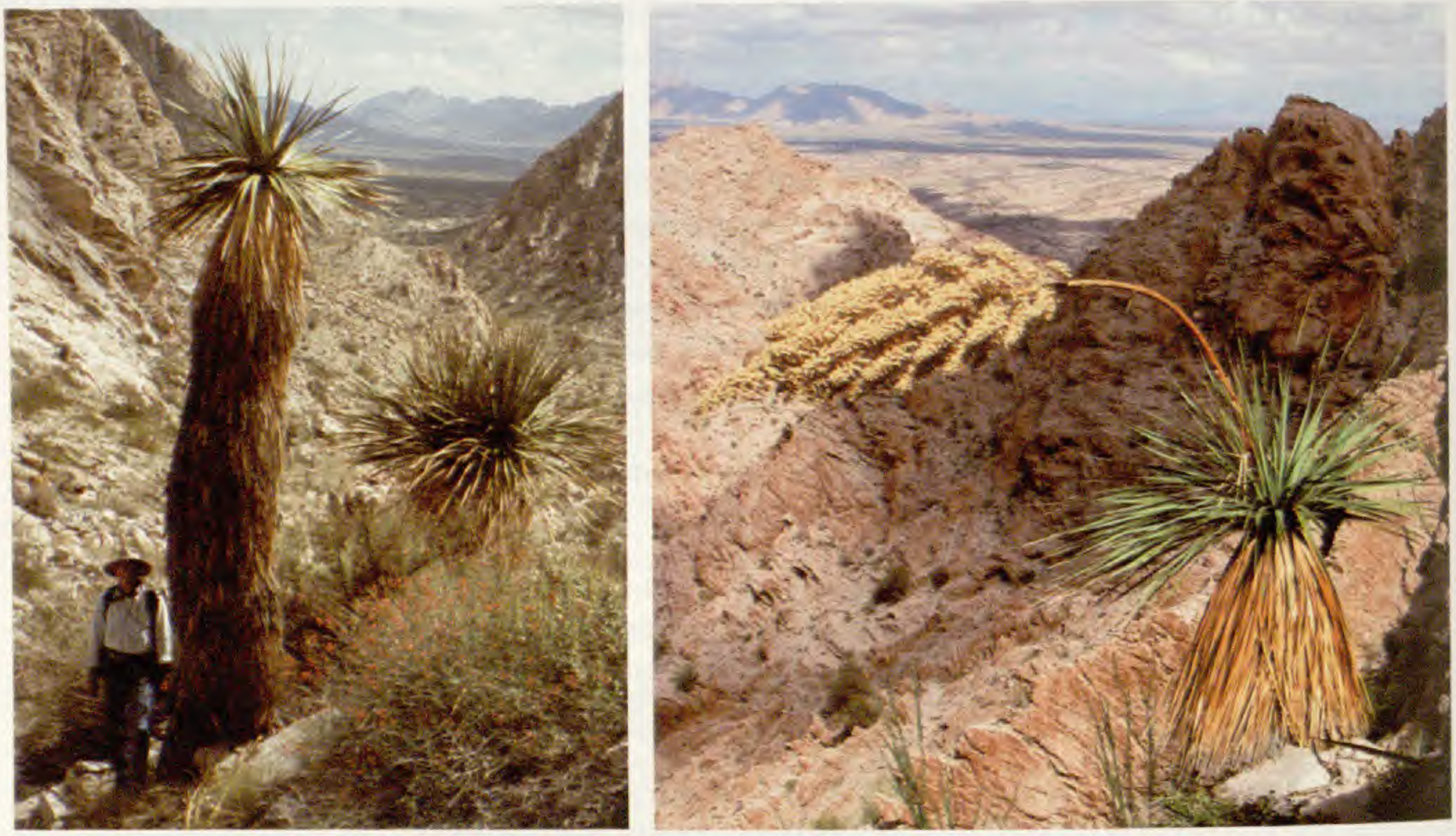

Fig. 21. Desert tree-beargrass (*Nolina bigelovii*). A) An exceptionally tall plant with Luke Evans, Frontera Canyon, 18 March 1998. B) Upper elevation in the Tinajas Altas Mountains above the tinajas, 25 October 2009. Photos by RSF.

NOLINACEAE, SEE **ASPARAGACEAE**

POACEAE—GRASS FAMILY

Grasses are the second largest family in the flora. The 18 species in the present-day flora represent 8% of the total flora, as compared to the 14% of the flora of adjacent northwestern Sonora (Felger 2000). Three additional species are known from the flora area only by fossils. Eight present-day grass species in the flora are annuals (ephemerals) and 7 are tufted perennials, although some of the perennials may become reproductive in the first season. Four species are native to the Old World.

Thirteen grass species have been found in the fossil packrat middens. Three of them, *Bouteloua repens*, *Festuca microstachys*, and *Setaria macrostachya*, are no longer present in the flora area and today are found in less harsh areas to east of the flora area. Identifiable fragments of the fossils include fragments of inflorescences and reproductive structures that may include spikelets or even spikes or spikelet clusters, florets, caryopses ("grain"), or combinations or pieces of these parts.

1. Plants with stolons and/or rhizomes; perennials.
    2. Stems often more 40 cm tall; rhizomes stout and firm; inflorescence elongated and spike-like, overtopping the leaves, more than 4 cm long, less than 1.5 cm wide; spikelets in clusters of 3s ____ Hilaria
    2. Plants less than 15 cm tall, with slender, flexible stolons; flowering stems less than twice as tall as the leaves, the inflorescence branches densely crowded (fascicled); spikelets not in clusters of 3 ____ Dasyochloa
1. Plants without conspicuous stolons or rhizomes; annuals or perennials.
    3. Spikelets enclosed in bristly fascicles falling as a unit, the bristles flexible and feathery (plumose) ____ Cenchrus
    3. Spikelets not enclosed in bristly fascicles.
        4. At least some spikelets with awns.
            5. Annuals; awns not more than 2.5 cm long.
                6. Spikelets multiple flowered.
                    7. Summer annuals (occasionally weakly responding to rains at other seasons or surviving after summer-fall rains); stems with 1-sided spikes (spicate branches), the spikes 2 or more and racemose, the spikes comb-like (the spikelets in a pectinate pattern) or the spikes needle-arrow shaped; individual spikelets 2 or more-flowered including awned rudiments, the fertile florets and rudiments very different from each other ____ Bouteloua

7. Cool-season annuals; spikes symmetrical or laterally compressed, but not 1-sided; sterile florets if present not appreciably different from the fertile florets except in size.

8. Spikelets 12–40 mm long (not including awns); lemmas 8–13 mm long; awns 12–25 mm long **Bromus**

8. Spikelets 8–13 mm long (not including awns); lemmas 4–8 mm long; awns 1–8 mm long **Festuca**

6. Spikelets 1-flowered.

9. Spikelets usually 3-awned; without cleistogamous spikelets **Aristida**

9. Spikelets 1-awned and also producing unawned cleistogamous spikelets near the base of the plant **Muhlenbergia**

5. Tufted perennials; awns 2 or more cm long.

10. Old leaves semi-persistent and reddish brown or rust colored; inflorescences solitary and spike-like; awns 4.5–7 cm long **Heteropogon**

10. Old leaves drying straw color; inflorescences of panicles or clusters of spike-like branches; awns 2–4.5 cm long.

11. Inflorescence cottony, of short branches clustered near top of stem; awns ca. 2 cm long, the basal portion twisted and not feathery **Bothriochloa**

11. Inflorescence an elongated spike-like panicle, not cottony; awns 3.3–4.5 cm long, bent, the basal portion feathery (plumose) and not twisted **Stipa**

4. Spikelets not awned

12. Annuals.

13. Summer annuals; glumes shorter than the spikelet; lemmas not notched **Eragrostis cilianensis**

13. Cool-season annuals; glumes about as long as the rest of the spikelet; lemmas notched (bifid) **Schismus**

12. Tufted perennials.

14. Inflorescences and spikelets cottony with silky, white to purplish hairs **Digitaria californica**

14. Inflorescences and spikelets not cottony; spikelets glabrous or pubescent but the hairs not silky.

15. Panicle partially enclosed by an inflated leaf-sheath (often with a reduced blade), the upper part of the panicle often becoming free and the branches spreading; spikelets 1-flowered **Sporobolous**

15. Panicles narrow and contracted; spikelets several-flowered **Tridens**

ARISTIDA—THREEAWN; *ZACATE TRES BARBAS*

Annuals and perennials. Spikelets 1-flowered, readily breaking off above the glumes (often lodging in socks—people might be supplanting animals as dispersal agents). Lemma hard at maturity, slender and terete, narrowing into an awn column bearing 3 awns, but sometimes the awns reduced or absent.

1. Annuals; awns flattened with minutely serrated margins (seen with at least 10× magnification), the awns reaching 1.5 (1.7) cm long (or awns occasionally very reduced, especially the lateral ones) **A. adscensionis**

1. Perennials (sometimes flowering in first season); awns terete, (1.6) 2 cm long or more **A. purpurea**

Aristida adscensionis L. SIX-WEEKS THREEAWN; *ZACATE TRES BARBAS*

Non-seasonal annuals, the roots often weakly developed. Spikelets with 3 awns or sometimes the 2 lateral ones, or all awns, reduced or absent on drought-stressed plants.

Seasonally common across the flora area, from lowest to highest elevations. This is the only annual *Aristida* in the Sonoran Desert. It has been in the region for more than 10,650 years.

Tinajas Altas, *Felger 04-69*. Tinajas Altas Pass, *Reeves R5416* 9 (ASU). Camino del Diablo at Coyote Wash, *Felger 10-165*. †Butler Mts, 8160–10,615 ybp. †Tinajas Altas Mts, 5080–10,070 ybp (3 samples; Van Devender et al. 1990b: 341).

Aristida purpurea Nutt. var. **nealleyi** (Vasey) Allred [*A. glauca* (Nees) Walp.] PURPLE THREEAWN; *TRES BARBAS*

Tufted perennials; flowering response non-seasonal.

Tinajas Altas and Butler Mountains. The history of this variety extends to 9700 years in the Tinajas Altas Mountains and this or a similar species was in the Butler Mountains 11,300 years ago.

Butler Mts, *Van Devender 27 Mar 1983*. Tinajas Altas, *Vorhies 16 Apr 1924*. †Butler Mts, 6490 ybp (Van Devender et al. 1990b: 342). †Tinajas Altas Mts, 4010 & 9700 ybp (Van Devender et al. 1990b: 341). †*A.* cf. *purpurea*, Butler Mts, 6490 to 11,250 ybp (3 samples, Van Devender et al. 1990b: 342).

Bothriochloa barbinodis (Lag.) Herter [*Andropogon barbinodis* Lag.] CANE BLUESTEM; *ZACATE POPOTILLO*

Robust tufted perennials; growing and reproductive during warm weather.

One small population was seen in Frontera Canyon and other small populations are known from a few scattered waterholes in Cabeza Prieta Refuge and the Gila Mountains.

Tinajas Altas, canyon bottom just above uppermost tinaja, 19 Mar 1998, *Felger* (observation).

BOUTELOUA—GRAMA GRASS; *GRAMA*

The present-day grama grasses in the core area (most arid portion) of the Sonoran Desert are summer annuals, often short-lived and with weakly developed root systems, and the basal leaves sparse and the internodes between them readily visible.

1. Inflorescence branches (spicate branches) needle-arrow shaped, with 1–4 slender spikelets closely appressed to the spike axis (spikelets scarcely spreading) ______ **B. aristidoides**
1. Spicate branches pectinate (comb shaped), often with 20–50 spikelets, these crowded in a double row, the spikelets perpendicular to the spike axis ______ **B. barbata** var. **barbata**

Bouteloua aristidoides (Kunth) Griseb. [*B. aristidoides* var. *arizonica* M.E. Jones] SIX-WEEKS NEEDLE GRAMA; *ACEITILLA, NAVAJITA AGUJA*

Summer annuals, the roots often weakly developed.

Seasonally common and widespread from the Lechuguilla Valley to at least 1700 ft in mountain canyons. It has been in the region for at least 11,300 years.

Bouteloua aristidoides is generally more numerous and extends onto drier sites than does *B. barbata*. Both sometimes weakly occur with cool-season rains or survive beyond the summer-fall season. These two species are among the most common hot-weather annuals in the Sonoran Desert.

Coyote Water, *Felger 04-31*. Tinajas Altas, above the tinajas, 19 Mar 1998, *Felger* (observation). 150 m N of Raven Peak (700 m SSW of Raven Butte), steep draw, *Walter & Morrison 584* (ASU). †Butler Mts, 610–11,250 ybp (6 samples; Van Devender et al. 1990b: 342). †Tinajas Altas Mts, 4010 & 8700 ybp (Van Devender et al. 1990b: 341).

Bouteloua barbata Lag. var. **barbata.** SIX-WEEKS GRAMA; *NAVAJITA, ZACATE LIEBRERO*; S-CUK MUDADT-KAM

Summer annuals, the roots often weakly developed. Anthers either orange or white.

Widespread from the Lechuguilla Valley and to at least 1700 ft in mountain canyons.

Coyote Water, *Felger 04-32*. Tinajas Altas, *Felger 04-70.*

†Bouteloua barbata var. **barbata** &/or var. **rothrockii** (Vasey) Gould [*B. rothrockii* Vasey]

One or perhaps both varieties of this grama grass are represented in the fossil record from about 5000 and 8700 years ago in the Tinajas Altas Mountains (in Organ Pipe Monument for at least 21,900 years). The two taxa are distinguished by growth form (annual for var. *barbata*, perennial for var. *rothrockii*), not by reproductive structures, and cannot be distinguished by the fossils, which are reproductive fragments.

†Tinajas Altas Mts, 5080 & 8700 ybp (Van Devender et al. 1990b: 341).

†Bouteloua repens (Kunth) Scribn. & Merr. [*B. filiformis* (E. Fourn.) Griffiths] SLENDER GRAMA; *NAVAJITA DELGADA*

Tufted perennials, generally growing with warm weather.

Documented for 8200 years ago in the Butler Mountains. The nearest present-day populations are in the Puerto Blanco and Ajo Mountains and locally elsewhere in Arizona Upland portions of Organ Pipe Monument.

†Butler Mts, 8160 ybp (Van Devender et al. 1990b: 342).

***Bromus madritensis** L. subsp. **rubens** (L.) Husn. [*B. rubens* L.] RED BROME; *BROMO ROJO*

Cool-season annuals; inflorescences brush-like at maturity. Lemmas with slender, bifid terminal lobes, and an awn 12–26 mm long, stiff, stout, straight or slightly curved

This invasive grass, native to the Old World, has become abundant in southern Arizona and across the northern part of Sonora, and is thoroughly established in Organ Pipe Monument, Cabeza Prieta Refuge, and the Sierra El Pinacate, but as of 2010 it was not common in the Tinajas Altas region. Unlike at least most native annuals, red brome does not produce dormant seeds and does not maintain a seed bank in the soil (Salo 2004).

Camino del Diablo at Coyote Wash, *Felger 02-8*. Tinajas Altas, *Felger 05-483.*

***Cenchrus ciliaris** L. [*Pennisetum ciliare* (L.) Link] BUFFELGRASS; *ZACATE BUFFEL*

Robust perennials and often flowering in the first season; growing and flowering during the warmer months.

Buffelgrass is well established along Mexico Highway 2 across northwestern Sonora and has spread northward into the larger washes and canyons at the southern tip of the Tinajas Altas Mountains. As of 2010 this usually invasive species had been seen in the Tinajas Altas region only along the international border.

Frontera Canyon, international border, not common, 18 Mar 1998, Felger (observation).

Dasyochloa pulchella (Kunth) Willd. ex Rydb. [*Erioneuron pulchellum* (Kunth) Tateoka. *Tridens pulchellus* (Kunth) Hitchc.] FLUFF GRASS; *ZACATE BORREGUERO*

Low, tufted perennials with slender, arching stolons. Flowering with warm weather and sufficient soil moisture; recruitment apparently occurs with summer rains. Seedlings may grow from the base of old, dry or dead plants, which serve as nurse plants.

Widespread in dry, open sites on mountains, hills, and upper bajadas. This is one of the most arid-inhabiting perennial grasses in the Sonoran Desert. It has been in the region for more than 10,300 years.

Camino del Diablo, SE of Raven Butte, *Felger 04-11*. Tinajas Altas, above upper tinajas, *Felger 04-92*. †Butler Mts, 220–11,250 ybp (9 samples; Van Devender et al. 1990b: 342). †Tinajas Altas Mts, 4010–10,300 ybp (5 samples; Van Devender et al. 1990b: 340).

Digitaria californica (Benth.) Henrard var. **californica** [*Trichachne californica* (Benth.) Chase] ARIZONA COTTONTOP; *ZACATE PUNTA BLANCA*

Tufted perennials; panicles narrow and densely flowered, the spikelets silky-cottony.

Only two plants of this grass were seen in the flora area, but perhaps it occurs at higher elevations in the mountains.

Tinajas Altas, one plant seen among rocks at base of tinaja slopes, *29 Dec 2005*, *Felger* (observation); 28 Mar 2010, *Felger 10-185* (one panicle collected).

***Eragrostis cilianensis** (Allioni) Vignolo ex Janch. STINK GRASS; *ZACATE APESTOSO*

Summer annuals. The spikelets bear small, wart-like glands that are turgid and glistening when fresh.

Seasonally common along Coyote Wash. Native to the Old World and well established in the Sonoran Desert. The Sonoran Desert plants are considerably smaller than those in more humid regions.

Coyote Water, *Felger 04-21*.

†Festuca microstachys Nutt. [*Vulpia microstachys* (Nutt.) Munro] SMALL FESCUE

Cool-season annuals. Documented in the flora area from 11,000 years ago. The nearest present-day populations are in the Ajo Mountains in Organ Pipe Monument. Four varieties are sometimes recognized, but they are not geographically well marked and do not seem worthy of recognition (Felger 2007b; var. *ciliata* A. Gray ex Beal is recorded for the Ajo Mountains).

†Tinajas Altas Mts, 10,950 ybp (Van Devender et al. 1990b: 340).

Festuca octoflora Walter [*F. octoflora* var. *hirtella* Piper. *Vulpia octoflora* (Walter) Rydb.] SIX-WEEKS FESCUE, EIGHT-FLOWERED FESCUE

Small, cool-season annuals; highly variable in size, 2.5–15+ cm tall.

Washes, upper bajadas, canyons, and mountains to at least mid-elevations. It has been in the flora area for at least 11,300 years.

Three varieties are sometimes recognized but are of doubtful significance (Felger 2000; Felger et al. 2007b). Present-day specimens are var. *hirtella*, characterized in part by pubescent spikelets (lemmas).

Tinajas Altas, 1450 ft, *Van Devender 10 Mar 1980*. Tinajas Altas, near lowermost tinaja, *Felger 10-186*. Coyote Water, *Felger 05-136*. †Butler Mts, 11,250 ybp (Van Devender et al. 1990b: 342). *F.* cf. *octoflora*: †Tinajas Altas Mts, 8970–10,950 ybp (4 samples; Van Devender et al. 1990b: 340).

Heteropogon contortus (L.) P. Beauv. ex Roem. & Schult. [*Andropogon contortus* L.] TANGLEHEAD; *ZACATE COLORADO*

Robust tufted perennials; dry leaves rust-colored and persistent. Spikelets bearing stout, brown, and twisted awns 4.5–7+ cm long. Reproductive during warmer months.

Canyon bottoms in the Tinajas Altas Mountains. Although some authors have claimed it is not native in the New World, it has been here at Tinajas Altas for at least 7900 years (Van Devender et al. 1990b).

Tinajas Altas Mts, 1200 ft, *Van Devender 25 Mar 1983*. †Tinajas Altas Mts, 5860–7860 ybp.

Hilaria rigida (Thurb.) Benth. ex Scribn. [*Pleuraphis rigida* Thurb.] BIG GALLETA; *TOBOSA*

Large, tufted perennials, forming dense clumps, the bases tough and knotty, with short, almost woody rhizomes. Growing and flowering primarily during the warmer months. Large, inflated galls often form in place of inflorescences.

Widespread on sandy soils across valley plains and bajadas, and sometimes locally in soil pockets on rocky slopes. It has been in the region for more than 10,400 years.

Coyote Water, *Felger 04-46*. Surveyors Canyon, *Felger 10-201*. Canyon above Tinajas Altas, 19 Mar 1998, *Felger* (observation). †Butler Mts, 3820–10,400 ybp (3 samples; Van Devender et al. 1990b: 342).

Muhlenbergia microsperma (DC.) Kunth. LITTLE-SEED MUHLY; *LIENDRILLA CHICA*

Non-seasonal annuals but best developed during cooler seasons. Spikelets 1-flowered. Lower leaf axils bear cleistogamous spikelets (self-fertilizing and not opening); terminal panicles branched and feathery, with chasmogamous spikelets (stamens and stigmas exposed) with awns 14–28 mm long.

Widespread at all elevations; most abundant in protected sites, especially among rocks and under spinescent shrubs (often eaten by animals in open sites); rocky slopes, canyons, bajadas, and washes. Its history in the region extends to 15,700 years.

Coyote Water, *Felger 04-51.* Tinajas Altas, *Van Devender 5 Mar 1983.* †Butler Mts, 750 ybp (Van Devender et al. 1990b: 342). †Tinajas Altas Mts, 8700–15,680 ybp (3 samples; Van Devender et al. 1990b: 341).

Pennisetum ciliare*, see **Cenchrus ciliaris

***Schismus arabicus** Nees [*S. barbatus* subsp. *arabicus* (Nees) Marie & Weiller] ARABIAN GRASS; *ZACATE ÁRABE*

Small, cool-season annuals. Widespread and well established in the flora area—most abundant on sandy soils of washes and valley plains, and also on rocky soils on slopes. Native to the Old World.

It was seen in the Tinajas Altas Canyon and on adjacent slopes near the uppermost waterhole, but not at higher elevations. The young stems and leaves of this invasive species often spread close to the ground, excluding or preventing other plants from sprouting (Felger 2000). This small grass and Sahara mustard (*Brassica tournefortii*) are the only two invasive species that appear to be impacting native plants in the flora area.

Coyote Water, *Felger 05-154.* Tinajas Altas, *Van Devender 5 Mar 1983.* Canyon below Raven Butte Tank, *Felger 10-243.* Tinajas Altas Canyon, ca. 1800 ft, canyon bottom near the uppermost tinaja, 19 Mar 1998, *Felger* (observation).

†Setaria macrostachya Kunth [complex, including *S. leucopila* (Scribn. & Merr.) K. Schumann] PLAINS BRISTLEGRASS; *ZACATE TEMPRANERO*

Perennial clumping grasses; growing and reproductive at various seasons, especially with summer-fall rains.

Documented for the Tinajas Altas Mountains with specimens 11,000 years old. The nearest known present-day population occurs in the Cabeza Prieta Mountains, mostly at higher elevations. It has been in the Ajo Mountains for at least 32,000 years (Van Devender et al. 1990b).

†Tinajas Altas Mts, florets, 10,950 ybp (Van Devender et al. 1990b: 341).

Sporobolus cryptandrus (Torr.) A. Gray. SAND DROPSEED; *ZACATE ARENERO*

Tufted perennials. Panicles enclosed by an inflated leaf-sheath (often with a reduced blade), the upper part of the panicle often but not always becoming free at maturity and the branchlets ultimately spreading. Known in flora area from a single record.

Tinajas Altas, 6 Dec 1935, *Goodding 599.*

Stipa speciosa Trin. & Rupr. var. **speciosa** [*Achnatherum speciosum* (Trin. & Rupr.) Barkworth. *Jarava speciosa* (Trin. & Rupr.) Peñailillo] DESERT NEEDLE GRASS

Perennials forming a dense basal clump of leaves, the leaf blades slender, tough, and rolled inward. Dormant during the coldest and also the hottest months. Growing and reproductive March to May and in fall.

Canyons and mostly north-facing slopes in the Tinajas Altas Mountains to at least 2200 ft. It has been in the flora area for at least 11,000 years. Maximum distribution seems to have been in the early Holocene and this grass is now widespread in the Mohave Desert. Like the Joshua tree, it seems to have expanded northward into Nevada during the last Ice Age/glacial period when it was still persistent in deserts in southwestern Arizona.

Borrego Canyon, *Felger 92-616.* Tinajas Altas, *Van Devender 26 Mar 1983.* 1 mi N of Tinajas Altas, *Kurtz 1164.* †Butler Mts, 3820 & 10,615 ybp (Van Devender et al. 1990b: 341–342). †Tinajas Altas Mts, 5860–10,950 ybp (7 samples; Van Devender et al. 1990b: 341).

Tridens muticus (Torr.) Nash var. **muticus.** SLIM TRIDENS

Tightly clumping small perennials with firm, slender stems, the stems and leaves often bluish glaucous. Apparently non-seasonal in growth and flowering response.

Common on rocky slopes and shallow soils in canyons, hills, and mountain slopes probably to the peaks.

Canyon above Tinajas Altas, *Felger 04-75.* N-facing slope near lowermost tank, 20 Nov 2008, *Felger* (observation). Borrego Canyon, 16 Jun 1992, *Felger* (observation).

THEMIDACEAE, SEE **ASPARAGACEAE**

TYPHACEAE—CATTAIL FAMILY

Typha domingensis Pers. SOUTHERN CATTAIL; *TULE*; 'UDUVHAG

Robust perennial herbs; winter dormant. Leaves upright, to 1.8 m long. The tiny, lightweight fruits (0.02–0.03 mg) with their associated hairs are produced in prodigious quantities and may be airborne over great distances, and probably are also bird-disseminated.

Cattails were seen at tinajas #4 (*see* Bryan 1925: 133) during the 1970s and 1980s, and a specimen was obtained in 2008 (**Fig. 22**). This is the only wetland plant species known from the Tinajas Altas Mountains. It occurs at scattered waterholes in nearby regions, including the Cabeza Prieta Refuge and northwestern Sonora, and is abundant along the lower Colorado River (Felger 2000; Felger et al. 2007b). Small local colonies or individual plants in nearby areas sometimes come and go with fluctuations in standing water.

Tinaja or pool #4 is a "shelf" Tinaja (about 25 ft perpendicular to flow), narrow (5 ft parallel to flow), nearly inaccessible pool midway up the plunge-pool series and above, not beside, the large wedged boulder. It is filled with sediment and Broyles has only once seen standing water in it, up to 60 cm deep, but the sediment undoubtedly holds moisture for a long time. *Typha* has not been seen at any other pool, for they may be too frequently scoured to support wetland plants.

Tinajas Altas tank, 10 Mar 1980, *Barry Spicer*, observation, in Van Devender field notes. A label for *Cheilanthes parryi* (*Engard 920*, 18 Apr 1976, ASU) states, "above the tinaja containing *Typha*." Tinajas Altas, "cattails at tanks," 12 Feb 1977, *Reeves* (observation recorded in his field notebook). Tinaja #4, sheltered trench in damp soil at the edge of the tinaja, 20 Nov 2008, *Wilder 08-383*.

DOUBTFUL, ENIGMATIC, AND POTENTIAL RECORDS

AMARANTHACEAE—AMARANTH FAMILY

Amaranthus palmeri S. Watson. CARELESS WEED, PIGWEED; *QUELITE DE LAS AGUAS*; CUHUGIA

Summer annuals; leaf blades mostly ovate. Male and female flowers on different plants; pistillate inflorescence bracts firm and often sharp; sepals not fringed; stamens 5.

Strangely, there are no records for it in the flora area, but we would expect it at least along Coyote Wash. It is common in nearby localities.

CONVOLVULACEAE—MORNING GLORY FAMILY

Jacquemontia pringlei A. Gray

Scandent or sprawling subshrubs, the upper stems often twining. Corollas white, becoming pale lavender as the flower ages during the day.

With one exception, the Ajo Mountains in Organ Pipe Monument is the most arid and westernmost record for the genus. The exception is an enigmatic specimen collected by Andrew Alexander "Nic" Nichol on 25 April 1938 at the "South end of Gila Mountains." Before the mid-twentieth century it was customary to include the Tinajas Altas Mountains in the concept of the Gila Mountains. On that same day Nichol collected *Muhlenbergia dumosa* in the "Mohawk Mountains" and *Aristida purpurea* in the "Gila Mountains." The muhly grass is likewise an enigmatic and tantalizing "extralimital" collection. In addition to canyons in the Tinajas Altas Mountains, other places such as a little side canyon in Spook Canyon in the Gila Mountains seem like a plausible place to support such plants, or perhaps Nichol's locality data is in error.

POACEAE—Grass Family

Aristida californica Thurb. var. **californica.** CALIFORNIA THREEAWN; *TRES BARBAS DE CALIFORNIA*

Non-seasonal perennials also flowering in the first season. This grass, characteristic of sandy soils, should be sought in portions of the Lechuguilla Mountains and sand soils on the west side of the Tinajas Altas Mountains. It is common on sand flats and dunes at the west side of Cabeza Prieta Refuge and in the Gran Desierto of Sonora just south of the flora area (Felger 2000; Felger et al. 2007b).

Cenchrus palmeri Vasey. GIANT SANDBUR; *HUIZAPORI*, *GUACHAPORI*

This unique grass has relatively large burs bearing sharp spines. Not known for the United States, but widespread on sandy soils in the nearby Gran Desierto almost to the Arizona border near Frontera Canyon. It should be sought on the Arizona side.

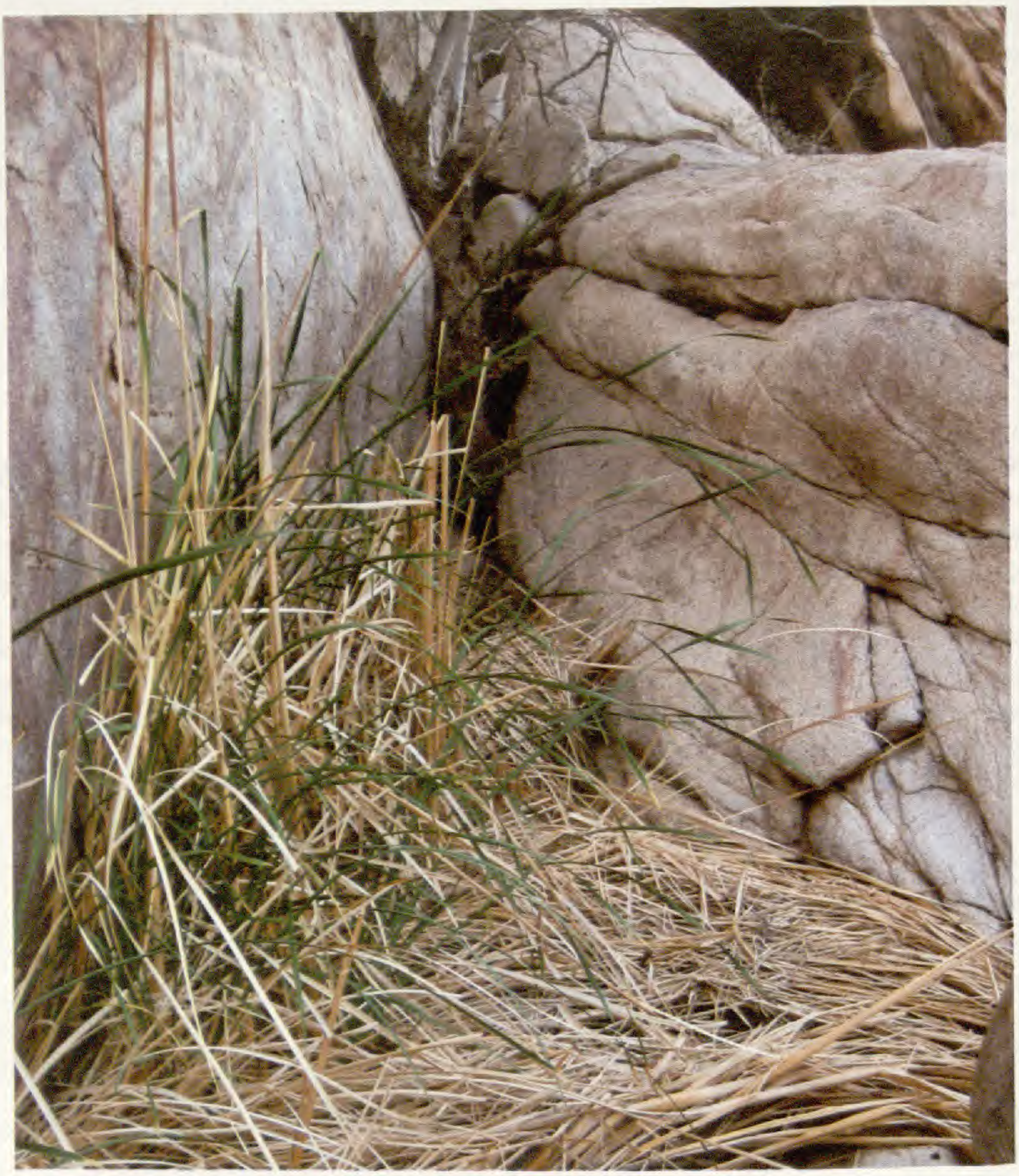

Fig. 22. Cattail (*Typha domingensis, Wilder 08-383*) at Tinajas Altas, tinaja #4. 20 November 2008. Photo by Benjamin T. Wilder.

ACKNOWLEDGMENTS

Over the years many different friends and colleagues have provided information and assistance, or accompanied us in the field. In this regard we thank Kelly W. Allred, A. Elizabeth (Betsy) Arnold, Daniel F. Austin, Thomas Bowen, Brad Boyle, Steven M. Buckley, Tony L. Burgess, J. Travis Columbus, Mark A. Dimmitt, Luke Taylor Evans, Mark Fishbein, Exequiel Ezcurra, Judy Ann Gibson, Edward Erik Gilbert, W. Eugene Hall, Stephen F. Hale, Gayle Harrison Hartmann, James L. Heard, James Henrickson, Wendy Caye Hodgson, Philip D. Jenkins, Sarah Lynn Johnson, the late Cynthia A. Lindquist, Elizabeth Makings, Curtis McCasland, Michelle McMahon, J. Mark Porter, Jeff Pralle, Adrianne G. Rankin, Jon P. Rebman, the late Charlotte Reeder and John Reeder, Karen Reichhardt, Rusty Russell, Susan Rutman, Andrew Salywon, Andrew C. Sanders, Silke Schneider, Richard Spellenberg, Victor Steinmann, Larry Toolin, Sula Vanderplank, Benjamin T. Wilder, and George Yatskievych. Cathy Moser Marlett drafted maps and Heidi Orcutt-Gachiri and Matt Schultz helped with another map. Adrian Quijada-Mascarenas translated the abstract. Sarah J. De Groot, Philip D. Jenkins, and Francisco Molina-Freaner provided a careful review of an earlier draft of the manuscript.

The authors thank the United States Marine Corps for encouragement of research on the Goldwater Range and generous support of this publication. Richard writes: I especially appreciate Bill Broyles introducing me to this great place and for good times in the field. Portions of the earlier work as well as more recent efforts were supported by the Wallace Research Foundation. Tom writes: I thank Paul S. Martin for stimulating my interest in packrat middens and secrets of the Ice Ages. Bill applauds the inclusive community of professional and amateur researchers who enthusiastically share their deep love and vast knowledge of the desert. Jim Malusa thanks the generous support of the United States Marine Corps, made possible by the efforts of Ronald L. Pearce, Abigail Rosenberg, Robert Palmer, Traci Allen, and Robert Lovich. Thanks, too, to Karen Reichhardt of the Yuma Field Office, Bureau of Land Management, who first introduced Malusa to the wonders of the western Goldwater Range.

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BOOK REVIEW

Eric Mader, Matthew Shepherd, Mace Vaughan, Scott Black, and Gretchen LeBuhn. 2011. **Attracting Native Pollinators: Protecting North America's Bees and Butterflies.** (ISBN: 978-1-60342-695-4, pbk.). Storey Publishing, 210 MASS MoCA Way, North Adams, Massachusetts 01247, U.S.A. (**Orders:** www.storey.com). $29.95, 384 pp., color throughout, graphs/tables, 7" × 10".

The Xerces Society has produced a resource perfect for novices wanting to learn more about pollinators and their habitats. As an introductory guide, *Attracting Native Pollinators* assists the reader in learning the roles, importance, and challenges of pollinators as well as basic botanical and entomological terminologies, taxonomies, behaviors, and characteristics. Even though the book describes different types of pollinators, it particularly focuses on insects (bees, wasps, flies, butterflies, and beetles) with an emphasis on native bees.

Attracting Native Pollinators is organized in a way that allows the reader to easily navigate the pages that are relevant to her/his interests. The book is divided into five parts: Pollinators and Pollination, Taking Action (Strategies to help pollinators), Bees of North America, Creating a Pollinator-Friendly Landscape, and an appendix with ideas for educators and parents, glossary, and resources.

The book contains beautifully detailed pictures of the various pollinators and their host plants, which contribute to enhancing the reader's understanding of the material—especially for bee and flower identification. The fourth part of the book includes drawing of sample gardens that can assist the reader with landscape planning. Additionally, *Attracting Native Pollinators* includes a brief but informative regional native plant list. One of the most beneficial resources in this book is the native bee identifier, which includes over thirty pages of information with colorful pictures and illustrations.

While *Attracting Native Pollinators* provides only an overview of the aforementioned topics, it is an excellent resource for home-owners, educators, and novice farmers or land managers wanting to learn more about pollinators and their environments. From this book, the reader can gain the basic tools she/he needs to further research the issues as they pertain to the reader's local environments and needs.

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BOOKS RECEIVED/REVIEWS FORTHCOMING

Richard B. Primack. 2012. **A Primer of Conservation Biology, Fifth Editon.** (ISBN: 978-0-87893-623-6, pbk.). Sinauer Associates, 23 Plumtree Road, Sunderland, Massachusetts 01375, U.S.A. (**Orders:** www.sinauer.com). $74.95, 363 pp., color figures, graphs, tables, 7.25" × 9.25".

Emily Monosson. 2012. **Evolution in a Toxic World: How Life Responds to Chemical Threats.** (ISBN: 978-1-59726-976-6, hbk.). Island Press, 1718 Connecticut Ave., NW, Suite 300, Washington, DC 20009, U.S.A. (**Orders:** http://islandpress.org/index.html). $35.00 (hbk.), $29.95 (pbk.), 240 pp., 10 figures, notes, index, 6" × 9".

A fascinating look at the evolution of toxic chemicals!

Alex George. 2011. **A Banksia Album: Two Hundred Years of Botanical Art.** (ISBN: 978-0-642-27739-8, pbk. flexbound). National Library of Australia, Canberra ACT 2600, AUSTRALIA. (**Orders:** www.nla.gov.au/). $34.95, 128 pp., color throughout, 9.25" × 11.25".

Beautiful botanical art! Coffee table worthy!

Michael A. homoya. Forword by Marion T. jackson. 2012. **Wildflowers and Ferns of Indiana Forests: A Field Guide.** (ISBN: 978-0-253-22325-8, pbk.). Indiana University Press, 601 North Morton St., Bloomington, Indiana 47804, U.S.A. (**Orders:** www.iupress.Indiana.edu, 800-842-6796). $22.95, 438 pp., color throughout, 4.25" × 8.25".

J. Bot. Res. Inst. Texas 6(1): 258. 2012

A FLORISTIC INVENTORY OF DISMAL KEY AND FAKAHATCHEE ISLAND—TWO SHELL MOUNDS SITUATED WITHIN THE TEN THOUSAND ISLANDS REGION IN THE GULF OF MEXICO (COLLIER COUNTY, FLORIDA)

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ABSTRACT

Dismal Key and Fakahatchee Island are islands and shell mounds situated within the Ten Thousand Islands region in the Gulf of Mexico. Each island has three main kinds of habitats: coastal hardwood hammock, insolated terrain, and mangrove. The islands exhibit 63 families, 138 genera, and 172 species of vascular plants, collectively. One hundred and twenty-seven species are native to Florida. Sixteen species are listed as endangered or threatened within Florida. Celtis iguanaea, present on Dismal Key, might exist at solely three other locations in Florida.

Key Words: Dismal Key, Fakahatchee Island, flora, shell mounds, vascular plants

RESUMEN

Cayo Dismal y Fakahatchee Island son islas y depósitos de caparazones situados en la región de las Diez Mil Islas en el Golfo de México. Cada isla tiene tres tipos principales de hábitats: hileras de leñosas costeras, terreno soleado, y manglares. Las islas contienen 63 familias, 138 géneros, y 172 especies de plantas vasculares, colectivamente. Ciento veintisiete especies son nativas de Florida. Diez y seis especies están listadas como en Peligro o amenazadas en Florida. *Celtis iguanaea*, presente en Cayo Dismal, pudiera existir únicamente en otras tres localidades en Florida.

INTRODUCTION

This is the third of a series of papers focused on the flora of southwestern Florida (Wilder & McCombs 2006; Wilder & Roche 2009). Herein, we present the results of a study of the native and nonnative taxa of vascular plants growing wild on Dismal Key and Fakahatchee Island.

Dismal Key and Fakahatchee Island are, simultaneously, islands and massive shell mounds situated 3.7 miles apart within the Ten Thousand Islands region in the Gulf of Mexico, in Collier Co., Florida (Figs. 1, 2). The two islands are centered at N 25°53'27" and W 81°33'28", and at N25°52'15" and W 81°29'25", respectively. The area of each island is, approximately, 73 acres (Beriault et al. 2003). Beriault et al. (2003) ranked both islands, together with Chokoloskee Island and Russell Key, as " … the four largest and most extensive shell mound complexes in the Ten Thousand Islands." On each of the two islands the maximum elevation exceeds 20 feet (South Florida Water Management District 2010).

Prehistoric Indians constructed both islands from shells over a prolonged time period. The islands served them as platforms for habitation and, possibly, as waste dumps. Schwadron (2010) concluded, based on data from radio-carbon dating, that for large mounds ("shell work sites") within the Ten Thousand Islands region, most construction seems to have occurred from about 1900 to 900 years before the present, with a possible peak in construction at ca. 1600 to 1300 years before the present; however, parts of Dismal Key and Fakahatchee Island might be considerably older than that, according to studies of Horr's Island (an island within the Ten Thousand Islands region situated 5.6 miles northwest of Dismal Key). Based on data derived from radiocarbon dating, Russo (1991) concluded that Indians occupied the western portion of Horr's Island primarily between 3000 and 4000 years before the present, and to a lesser extent even earlier and later. The Calusa Indians were likely the last of a series of prehistoric/historic tribes to inhabit the Ten Thousand Islands.

Non Indians decimated and evicted the Indians and settled Dismal Key and Fakahatchee Island. Beriault

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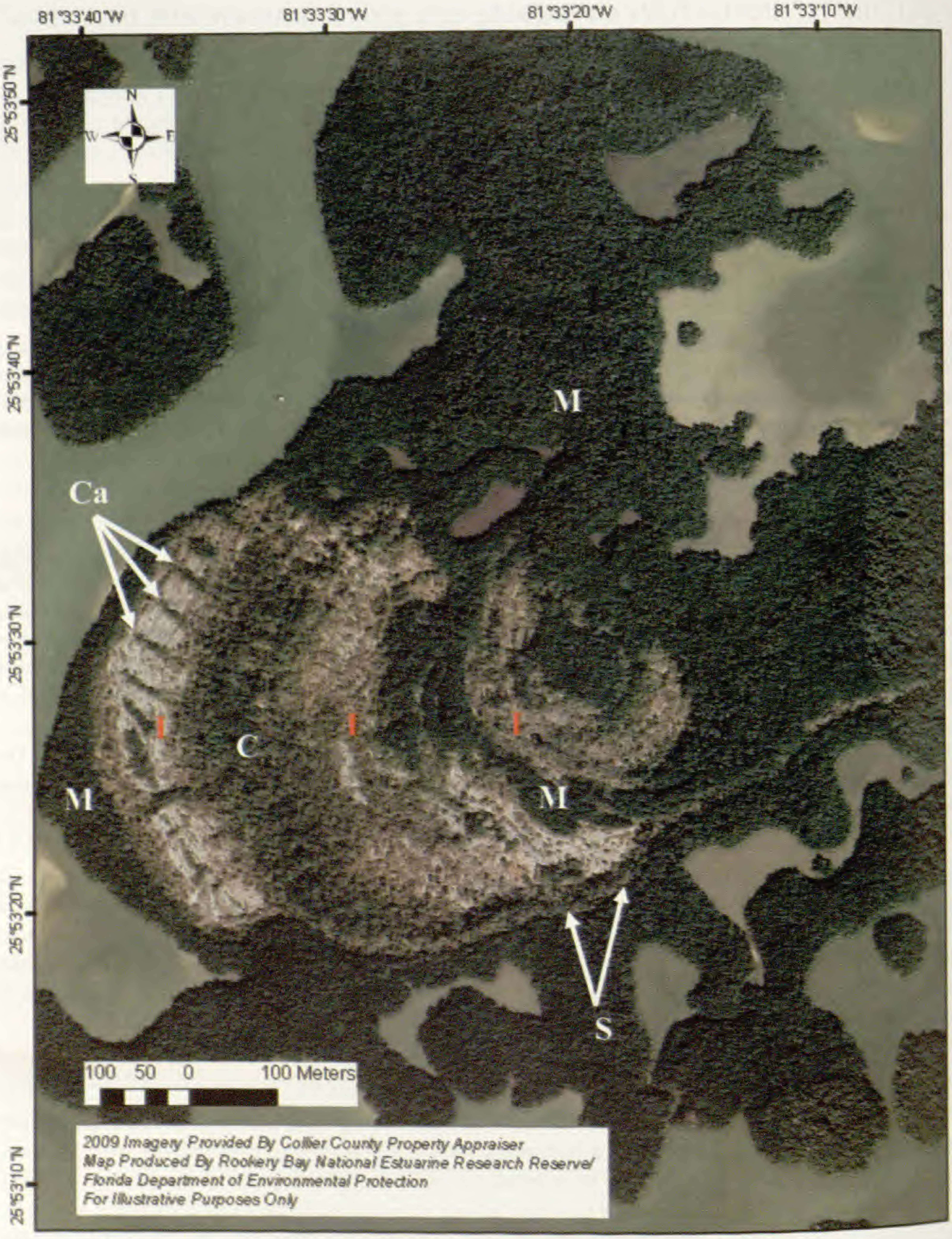
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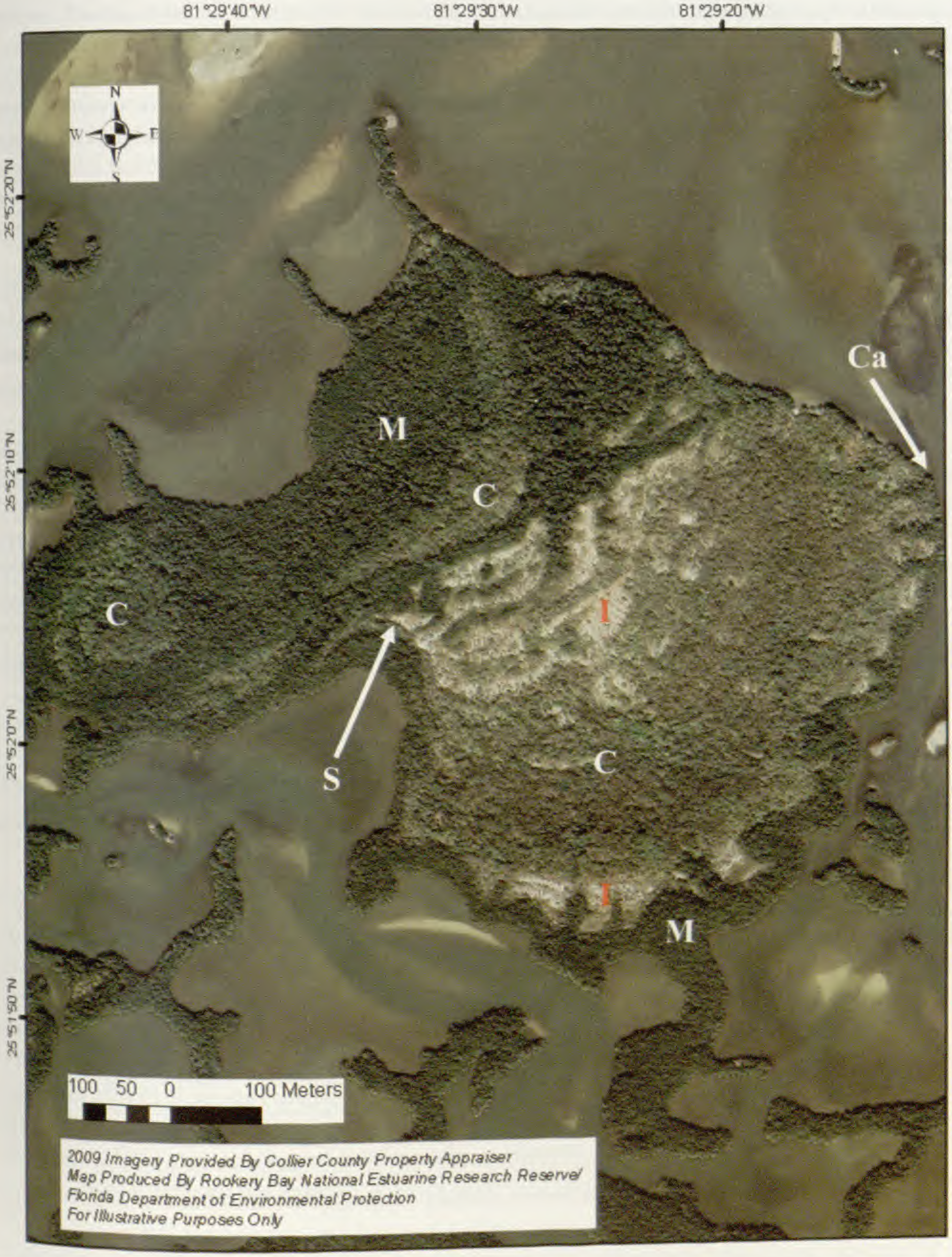
2009 Imagery Provided By Collier County Property Appraiser
Map Produced By Rookery Bay National Estuarine Research Reserve/
Florida Department of Environmental Protection
For Illustrative Purposes Only

Fig. 1. Aerial photograph of Dismal Key. **C.** Coastal hardwood hammock. **Ca.** Three trenches interpreted as canals. I. Insolated terrain; labeled from left to right are the western, median, and eastern crescents. **M.** Mangrove habitat. **S.** Apparent seawall. This photograph (without labels) was provided by the Office of the Collier County Property Appraiser and modified by Jill Schmid.


81°29'40"W
81°29'30"W
81°29'20"W
25°52'20"N
25°52'10"N
25°52'0"N
25°51'50"N
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2009 Imagery Provided By Collier County Property Appraiser
Map Produced By Rookery Bay National Estuarine Research Reserve/
Florida Department of Environmental Protection
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Fig. 2. Aerial photograph of Fakahatchee Island. **C.** Coastal hardwood hammock. **Ca.** Trench interpreted as a canal. **I.** Insolated terrain; labeled, are the broad median crescent (upper I) and the narrow, much interrupted crescent (lower I) that exists near the southern and eastern shores of the Island. **M.** Mangrove habitat. **S.** Apparent seawall. This photograph (without labels) was provided by the Office of the Collier County Property Appraiser and modified by Jill Schmid.

et al. (2003) reported historic artifacts and refuse from Dismal Key dating from the 1870s onward, and they indicated evidence for at least three distinct historic home sites on the Island. They also quoted from observations made by Hrdlička, in 1918, that much "high ground" on Dismal Key was then under cultivation. Also, until approximately 1980, a succession of hermits occupied a house on Dismal Key that was constructed, perhaps, in the 1920s or 1930s (Seely 2010). Fakahatchee Island was reportedly settled as early as 1870 (Tebeau 1966) and was subjected to "… long and intensive use by historic white settlers" (Beriault et al. 2003). The inhabitants farmed, raised livestock on, and fished near the Island. They constructed houses (including a schoolhouse), cisterns, and a small cemetery, and they left behind various artifacts. They departed from Fakahatchee Island, probably during the early-to-mid-1950s (Beriault et al. 2003; Seely 2010).

Today the islands are uninhabited and are included within a group of overlapping preserves. Dismal Key belongs both to the Ten Thousand Islands Aquatic Preserve and to the Ten Thousand Islands National Wildlife Refuge. Fakahatchee Island is included within the Ten Thousand Islands Aquatic Preserve. The Ten Thousand Islands Aquatic Preserve and Rookery Bay Aquatic Preserve, jointly, compose the Rookery Bay National Estuarine Research Reserve (Burch 1998).

We undertook the present study for three main reasons. First, we wished to compile a list of the plant species present on both islands. There existed no thorough, previously published flora or list of voucher specimens for either Island; however, Beriault et al. (2003) had produced a brief, undocumented list of species for each island; Burch (1998) had published an inventory of the vascular plants of the Rookery Bay National Estuarine Research Reserve; and, Barry (2009) had compiled unpublished lists of endangered, threatened, and exotic species of the Ten Thousand Islands National Wildlife Refuge. Second, we wished to document the island floras by vouchering inventoried species. Third, by implementing study immediately, rather than by delaying until the future, we desired to preempt the continuing rise in sea level that is likely to alter, and to eventually inundate, both islands.

Herein, besides addressing the three objectives, aforementioned, we briefly characterize the topography of the islands and certain relicts of human habitation, we describe the main kinds of habitats present on each island and we indicate the species that occupy each kind, and we compare Dismal Key and Fakahatchee Island, floristically, to other areas.

METHODS

George Wilder visited Dismal Key 23 times, from May 8, 2010 through Jan. 7, 2012, and Fakahatchee Island 24 times, from Aug. 6, 2009 through Dec. 10, 2011. Beginning in the early 1990s, Michael Barry independently visited the Islands, focusing greatest attention on them during 2005 through 2009. For each island, during our entire study each month of the year was represented by one or more visits; however, in any year we did not always visit an island during any two successive months. George Wilder vouchered species with dried herbarium specimens that were deposited at the Herbarium of Southwestern Florida (SWF), housed at the Naples Botanical Garden (Appendix 1). We characterize species as native, exotic, and endemic to Florida, according to Wunderlin and Hansen (2011), with the exception of *Carica papaya*, where we follow Ward (2011) and consider this species to be native. Mostly, our nomenclature follows Wunderlin and Hansen (2011); however, Appendix 1 (footnote 1) specifies nomenclatural differences between that work and the present paper.

RESULTS AND DISCUSSION

Topography and relicts of former habitation

Beriault et al. (2003) and Schwadron (2010) have provided detailed descriptions of these aspects. Presented here is a brief account that reflects personal observations. Dismal Key and Fakahatchee Island exhibit low-lying, relatively flat substrate, but additional topographic features interrupt the flat areas. For example, each island exhibits a prominent curved band of elevated substrate connecting two sides of the island; each band consists of conjoined, short ridges oriented perpendicular to the band's long axis. The islands are characterized by additional ridges. Some ridges occur inland, but on Dismal Key there also exists a massive ridge (an apparent seawall) situated just landward of the island's southern margin (i.e., in a position facing open ocean; Fig. 1, S); this seawall manifests a long extension that continues northeastward from the main body of the island. Fakahatchee Island exhibits a less obvious seawall (Fig. 2, S). An isolated tall mound known as Youman's Mound occurs within the westernmost hammock on Fakahatchee Island. Also, regularly spaced trenches—interpreted as the remnants of Indian canals—are oriented perpendicular to the shoreline, both along the western portion of Dismal Key and along the eastern and southern parts of Fakahatchee Island (Figs. 1, 2, Ca). A long trench extends northeastward across Fakahatchee Island. Mangrove vegetation dominates all trenches, aforementioned.

Both islands manifest relicts of the non Indian inhabitants. Cisterns occur on each island. The small cemetery (now enclosed by coastal hardwood hammock) remains on Fakahatchee Island. Likewise, on Fakahatchee Island there exists one (perhaps, a group of two) isolated grave(s) within the apparent seawall; an accompanying headstone memorializes Elizabeth Hart and her date of death (1892).

Habitats

Each island exhibits three main kinds of habitats: mangrove habitat, insolated terrain, and coastal hardwood hammock. In the aerial photograph of Fakahatchee Island (from 2009) these habitats appear dark green, ca. cream colored, and light green, respectively (Fig. 2, M, I, C). Insolated terrain is either barren or manifests low-growing vegetation, and its shell substrate is commonly exposed. In coastal hardwood hammock, topsoil covers the shell substrate.

Each island exhibits peripheral mangrove vegetation and mangrove habitat also occupies depressed areas inland (including the apparent Indian canals; Figs. 1, 2, M).

Insolated terrain defines three crescents on Dismal Key and two on Fakahatchee Island. On Dismal Key there occur a western crescent (traversed by the apparent canals), a median crescent, and an eastern crescent (Fig. 1, I). Crescents of insolated terrain are less defined on Fakahatchee Island, which exhibits one narrow crescent near the eastern and southern shores of the Island, and a broad median crescent (Fig. 2, I); both crescents are interrupted—that to the east and south being interrupted by canals, and both crescents being penetrated by other stands of trees and shrubs (Fig. 2). On each island some insolated terrain is remote from the crescents.

Coastal hardwood hammock covers the remainder of each island. On Dismal Key, hammock composes a large stand between the western and median crescents of insolated terrain (Fig. 1, C). On Fakahatchee Island, hammock defines a broad stand between the two crescents of insolated terrain; it also composes smaller stands northward and westward on the Island (Fig. 2, C). The westernmost stand of hammock is especially well developed and includes certain plant species that are absent from the other stands (*Chrysophyllum oliviforme, Mangifera indica, Petiveria alliacea, Psidium guajava*). On both islands hammock predominates on the elevated bands of substrate and it also lines the apparent seawalls and additional higher shell ridges.

Concentrated in places on each island, are armed species that manifest spines, thorns, and prickles, collectively: *Acacia tortuosa, Acanthocereus tegragonus, Agave decipiens, Celtis iguanaea, Erythrina herbacea, Opuntia humifusa, Opuntia stricta, Pisonia aculeata, Pithecellobium unguis-cati, Randia aculeata,* and *Sideroxylon celastrinum*. In particular, the dense concentrations of A. tetragonus and O. stricta (spinous species of Cactaceae) render parts of each island challenging and painful to traverse. Small (1922) reported comparable habitat at Caxambas (habitat no longer present there), a part of Marco Island within the Ten Thousand Islands region. Small indicated "…hills nearer the water … clothed with hammock which was made almost impenetrable by entanglements of prickly-pear [*Opuntia* sp.] and dildoe [*Acanthocereus tetragonus*], as well as by scraggly armed shrubs, all of which were laced together in the course of their growth." Based on Schimper (1903), Dismal Key and Fakahatchee Island—especially, their hammocks—likewise resemble the thorn-woodlands (including caatingas) that are widespread and often coastal within the American tropics.

Taxonomic Analysis of Present Data

The floras of both islands, collectively, include 63 families, 138 genera, and 172 species (not including sterile *Kalanchoe* sp. from Dismal Key, which might be equivalent to a *Kalanchoe* species from Fakahatchee Island;

Appendix 1). Between parentheses, for both islands together the numbers of families, genera, and species are indicated, respectively, for each of the following major groups of vascular plants: pteridophytes (2, 3, 3), angiosperms (61, 135, 169), monocotyledons (9, 23, 39) and dicotyledons (52, 112, 130). For species of each major group, their percentage of all 172 species is listed: pteridophytes, 1.7%; angiosperms, 98.3%; monocotyledons, 22.7%; and dicotyledons , 75.6%.

For both islands, collectively, the five largest families of monocotyledons, as gauged by the numbers of species present, are Poaceae (18), Bromeliaceae (8), Cyperaceae (5), Agavaceae (2), and Orchidaceae (2) (for each family, the number of species is listed between parentheses). The eleven largest families of dicotyledons on both islands, as gauged by the numbers of species present, are Fabaceae (15), Asteraceae (9), Euphorbiaceae (6), Solanaceae (6), Convolvulaceae (5), Malvaceae (5), Amaranthaceae (4), Cactaceae (4), Myrtaceae (4), Rubiaceae (4), and Sapotaceae (4).

Fakahatchee Island supports more species than does Dismal Key (151 vs. 135 species, respectively). Of all 172 species present, 113 species (65.7% of species) are shared by both islands. Gymnosperms and oaks are absent from the islands.

Species and Habitats

Habitat data presented herein are a summation of data from both islands. We noted: (1) one hundred and twenty-six species within insolated terrain; (2) ninety-four species within coastal hardwood hammock; and (3) thirty-six species within mangrove habitat (Appendix 1). We observed certain species solely at habitat boundaries: between insolated terrain and coastal hardwood hammock (9 species); between insolated terrain and mangrove habitat (5 species); and between coastal hardwood hammock and mangrove habitat (1 species). *Acalypha ostryifolia* and *Lantana camara* grew only within the cemetery on Fakahatchee Island. *Antigonon leptopus* (not tallied above) and *Senna ligustrina* (tallied above solely for insolated terrain) grew both within the cemetery and at the boundary between coastal hardwood hammock and insolated terrain.

Individuals of *Tillandsia* species are abundant on both islands and we noted all eight of the observed *Tillandsia* species in all of the three main kinds of habitats (Appendix 1). Twelve species of other genera also occur in all three habitat types: *Acanthocereus tetragonus, Alternanthera flavescens, Capparis flexuosa, Capparis jamaicensis, Cissus verticillata, Conocarpus erectus, Encyclia tampensis, Ipomoea indica, Opuntia stricta, Pisonia aculeata, Schinus terebinthifolia,* and *Sideroxylon celastrinum*.

Native and Endemic Taxa

Native species included 127 of the 172 species (73.8%) recorded (this calculation does not include *Oxalis* sp., which was sterile and, therefore, not clearly native or exotic; Appendix 1). Dismal Key and Fakahatchee Island exhibit 111 and 113 native species, respectively, these numbers representing 82.2% and 74.8% of species on each of the islands, respectively. *Agave decipiens*, noted from both islands, is the sole species presently reported that is endemic to Florida.

Native Species Listed as Rare in Florida

The two islands are havens for rare species (Table 1). Sixteen presently reported species (12.6% of all native species present) are listed as Endangered (nine species) or Threatened in Florida (seven species; Weaver & Anderson 2010). For South Florida, one species listed as Historical and three listed as Critically Imperiled (Gann et al. 2002) were documented during this study. Occurring on both islands, are each of six endangered species (*Cheilanthes microphylla, Cyperus filiformis, Gossypium hirsutum, Setaria chapmanii, Tillandsia fasciculata,* and *Tillandsia utriculata*) and each of six threatened species (*Acanthocereus tetragonus, Chrysophyllum oliviforme, Myrcianthes fragrans, Opuntia stricta, Tillandsia balbisiana,* and *Tillandsia flexuosa*). Dismal Key exhibits two additional endangered species (*Acacia tortuosa, Celtis iguanaea*) and Fakahatchee Island manifests one additional endangered species (*Celosia nitida*) and one other threatened species (*Maytenus phyllanthoides*).

Acanthocereus tetragonus, Opuntia stricta, and *Cyperus filiformis* are abundant on both islands. During 2010, we saw thousands of individuals of *C. filiformis* on Fakahatchee Island, but that species was hard to find there in 2011; during 2011, we also observed hundreds of plants at localized sites on Dismal Key. Previously, in

TABLE 1. List of the species of rare plants of Dismal Key and Fakahatchee Island. Rankings of rarity are for Florida (Weaver & Anderson 2010) and for south Florida (Gann et al. 2002). **Crit. Imp.** = critically imperiled; **End.** = endangered; **Hist.** = historical; **Threat.** = threatened.

Taxon	Weaver & Anderson (2010)	Gann et al. (2002)
Acacia tortuosa	End.	Hist.
Acanthocereus tetragonus	Threat.	
Celosia nitida	End.	
Celtis iguanaea	End.	Crit.Imp.
Cheilanthes microphylla	End.	Crit.Imp
Chrysophyllum oliviforme	Threat.	
Cyperus filiformis	End.	Crit.Imp.
Gossypium hirsutum	End.	
Maytenus phyllanthoides	Threat.	
Myrcianthes fragrans	Threat.	
Opuntia stricta	Threat.	
Setaria chapmanii	End.	
Tillandsia balbisiana	Threat.	
Tillandsia fasciculata	End.	
Tillandsia flexuosa	Threat.	
Tillandsia utriculata	End.	

1965 in the Ten Thousand Islands region, Olga Lakela had collected *C. filiformis* on Chokoloskee Island, but that locality was later developed, probably eliminating the species there (Gann et al. 2002).

Several listed species are confined to a single to several sites on each island (*Cheilanthes microphylla*, *Gossypium hirsutum*, *Setaria chapmanii*). In Florida, *Cheilanthes microphylla* is known from six counties situated within the southern, central, and northern portions of the Florida peninsula and within the Florida Panhandle (Wunderlin & Hansen 2011a). Previous workers had reported C. microphylla from three localities located in the Ten Thousand Islands region: Turner River Mound, Horr's Island, and an unspecified island in Addison Bay; however, the Horr's Island population may no longer survive .There also exists a questionable report of *C. microphylla* from Miami-Dade County (Gann et al. (2002).

Acacia tortuosa was formally reported from Florida, solely from three localities situated within the Ten Thousand Islands region: Chokoloskee Island, Dismal Key, and Ferguson's Mound; however, the Chokoloskee plants were likely destroyed (Barry 2009; Gann et al 2002; Wunderlin & Hansen 2011a). Recently, Jimi Sadle, botanist at the Everglades and Dry Tortugas National Parks, has also observed *A. tortuosa* within the Ten Thousand Islands region, at Russel Key and Sandfly Island (pers. comm. to Michael Barry, of Feb. 29, 2012).

On Fakahatchee Island we noted *Chrysophyllum oliviforme* only in rich hammock by the island's western end, but the species was more widespread on Dismal Key. *Maytenus phyllanthoides* was limited to two small, closely associated sites on Fakahatchee Island.

Celtis iguanaea is the rarest listed species that we encountered, and we observed it solely at one site on Dismal Key. Always scarce in Florida, it may now persist there solely on Dismal Key and on three other islands within the Gulf of Mexico: Big Mound Key (Charlotte Co.), Gopher Key (Monroe Co.), and Mound Key (Lee Co.). According to Gann et al. (2002), earlier workers had documented *C. iguanaea* in south Florida, on Horr's Island (within the Ten Thousand Islands region) and on Sanibel Island, Captiva Island, and Mound Key (additional islands within the Gulf of Mexico); however, *C. iguanaea* was extirpated, or probably extirpated, later on, on the first three of those islands (Gann et al. 2002). (Mitch Thompson—an amateur botanist and former surveyor of Horr's Island—personally observed that the single plant on Horr's Island was dug-up during archaeological research [personal communication to George Wilder, of Dec. 15, 2011]). One of us (Michael Barry) discovered *C. iguanaea* at Big Mound Key (in 1993) and, together with Ian Bartoszek, he also found it at Gopher Key (in 2010)—two locations where the species likely persists (unpublished information).

Celtis iguanaea is a tropical species that reaches a northern limit in south Florida. It ranges from south Florida, Texas, and the Bahama Islands southward through Mexico and Mesoamerica to Peru, Paraguay, and

Uruguay (Austin 2004; Correll & Correll 1982). The plants are described as trees, shrubs, and climbing shrubs (Austin 2004; Correll & Correll 1982; Gann et al. 2002; Long & Lakela 1976; Nelson 1996); however, the individuals at Dismal Key were vines that extended both along the ground and high into the forest canopy. The main stems were thick, thorny, and ropelike, and a stem and its branches, jointly, sometimes approached 100 feet long. We suspect that our material was a clone, because (a) one thick stem was rooted at two separate places along the ground, suggesting possible asexual reproduction, (b) all vines were rooted fairly close to one another, and (c) fruits were rare, suggesting possible absence of cross pollination.

Species that are Rare on Dismal Key and Fakahatchee Island

On each island there exists a considerable number of species that are represented solely by one to several individuals or presumed clones. Those species, indicated in Appendix 1, vary from rare to common in Florida, overall.

Exotic Species

Forty-four species are exotic within Florida (not counting *Kalanchoe* sp; Appendix 1). Certain exotic species are probably escapes from previous cultivation on the islands. They include fruit trees (*Annona squamosa, Citrus sp., Dimocarpus longan, Mangifera indica, Manilkara zapota, Psidium guajava, Spondias purpurea*) and other horticultural plants (*Agave sisalana, Aloe vera, Antigonon leptopus, Catharanthus roseus, Cereus repandus, Cryptostegia grandiflora, Delonix regia, Euphorbia tirucalli, Jatropha gossypifolia, Kalanchoe species, Lantana camara, Leucaena leucocephala, Sansevieria hyacinthoides, Schinus terebinthifolia, Senna atomaria, Tecoma stans,* and *Thespesia populnea*). Escapes are most problematical on Fakahatchee Island, where six species, aforementioned, compose dense colonies: *Aloe vera, Cereus repandus, Agave sisalana, Euphorbia tirucalli, Sansevieria hyacynthoides,* and *Schinus terebinthifolia. Schinus terebinthifolia* is also problematical on Dismal Key.

The Florida Exotic Pest Plant Council (FLEPPC) recognizes two categories of plant species exotic within Florida, that pose especial threats to the ecology of the State, overall, i.e., Category I and Category II (these categories indicate decreasing degree of threat; Florida Exotic Pest Plant Council 2011). We noted seven Category I species: three from both islands (*Manilkara zapota, Melinis repens, and Schinus terebinthifolia*) and four solely from Fakahatchee Island (*Colubrina asiatica, Lantana camara, Psidium guajava,* and *Thespesia populnea*). Seven Category II species also occurred: three from both islands (*Antigonon leptopus, Dactyloctenium aegyptium,* and *Stachytarpheta cayennensis*) and four from Fakahatchee Island (*Agave sisalana, Kalanchoe pinnata, Leucaena leucocephala,* and *Sansevieria hyacinthoides*). The Category I and Category II species on both islands comprised 9.3% and 9.6% of all 75 Category I species and 73 Category II species recognized for Florida, respectively.

Comparisons with Previous Studies

Previous workers, apparently, collected minimally on Dismal Key and Fakahatchee Island. Although, we visited four virtual herbaria, we located solely five herbarium specimens collected from the islands, from FTG and USF (The New York Botanical Garden 2011; University of Florida Herbarium Collections Catalog 2011; Virtual Herbarium 2011; Wunderlin & Hansen 2011a.). The specimens, which represented four species, were from Dismal Key (*Leptochloa dubia, Senna atomaria*) and Fakahatchee Island (*Eugenia axillaris, Piscidia piscipula*). We also noted the same four species during current field work (Appendix 1). Perhaps, as virtual herbaria are updated additional specimens from the islands will be represented online.

Beriault et al. (2003) reported 52 species from Dismal Key and approximately 53 species from Fakahatchee Island. They listed *Eugenia uniflora* for both islands, a species that we do not report presently. Unlike ourselves, for Dismal Key they also listed *Kalanchoe pinnata* and *Spathodea campanulata*, and for Fakahatchee Island they reported *Dalbergia ecastaphyllum, Eugenia foetida,* and short-leafed fig (probably *Ficus citrifolia*; John Beriault, personal communication of Dec. 30, 2011). We did report sterile *Kalanchoe* sp. for Dismal Key which might correspond to the *Kalanchoe pinnata* that Beriault et al. (2003) found there.

We documented five species as new for Collier County: *Aloe vera, Cereus repandus, Dimocarpus longan, Setaria chapmanii,* and *Sporobolus pyramidatus* (The Florida State University Biology Department Robert K. Godfrey Herbarium 2011; The New York Botanical Garden 2011; University of Florida Herbarium Collections Catalog 2011; Virtual Herbarium 2011; Wilder & McCombs 2006; Wilder & Roche 2009; Wunderlin & Hansen 2011a). Also, fifty-two species represent additions to Burch's (1998) inventory of the vascular plants of Rookery

TABLE 2. Comparisons made with previously published inventories of vascular plants. Between parentheses, following a species name the letter *R* signifies a species presently documented that represents an addition to Burch's (1998) inventory of the vascular plants of Rookery Bay National Estuarine Research Reserve; *M* indicates a species presently documented that Wilder and Roche (2009) and previous workers had not documented during previous studies of Marco Island. * = a species exotic within Florida; all other species, possibly excluding *Oxalis* sp., are native to Florida.[1]

Abutilon permolle (R, M)
Acacia tortuosa (R, M)
Acalypha ostryifolia (R, M)
**Agave sisalana* (R)
**Aloe vera* (R, M)
**Annona squamosa* (R, M)
**Antigonon leptopus* (R)
Argemone mexicana (R)
**Bothriochloa ischaemum* (R, M)
**Bothriochloa pertusa* (R)
Cakile lanceolata (M)
Celosia nitida (R, M)
Celtis iguanaea (R, M)
**Cereus repandus* (R, M)
Chamaesyce ophthalmica (R)
Cheilanthes microphylla (M)
Chromolaena odorata (R, M)
Cissus trifoliata (M)
Coccoloba diversifolia (M)
**Cryptostegia grandiflora* (R, M)
Cynanchum angustifolium (R)
Cyperus filiformis (R, M)
Cyperus ovatus (R)
Cyperus planifolius (R, M)
**Dicliptera sexangularis* (M)
Digitaria ciliaris (R)
**Dimocarpus longan* (R, M)
**Eragrostis ciliaris* (R)
**Euphorbia tirucalli* (M)
Galactia striata (R)
Gossypium hirsutum (M)
**Heteropogon contortus* (R)
Ipomoea alba (R)
Ipomoea hederifolia (R, M)
**Jatropha gossypifolia* (R, M)[2]
**Kalanchoe daigremontiana* (R)
**Kalanchoe delagoensis* (R)
Lasiacis divaricata (R, M)
Leptochloa dubia (R, M)
Malvastrum corchorifolium (R)
**Manilkara zapota* (M)
Maytenus phyllanthoides (R, M)
Oxalis sp. (R)
Pectis glaucescens (R, M)
Pentalinon luteum (R)
Physalis angulata (M)
Plumbago zeylanica (R)
Portulaca rubricaulis (R,M)
**Senna atomaria* (R, M)
Senna ligustrina (M)
**Senna obtusifolia* (R)
Setaria chapmanii (R, M)
Setaria macrosperma (R)
**Solanum lycopersicum* (R)
**Spondias purpurea* (R, M)
Sporobolus domingensis (R)
Sporobolus pyramidatus (R, M)
**Stachytarpheta cayennensis* (R)
**Tecoma stans* (R)
Tournefortia volubilis (R)
**Urochloa distachya* (R)
**Urochloa fusca* (R)

[1] Burch listed no species of *Oxalis*. Because we could not identify our sterile *Oxalis* material to species, we could not ascertain whether it was native or exotic.

[2] Burch (1998) listed *Jatropha* sp. as the sole species of *Jatropha*.

Bay National Estuarine Research Reserve; 29 and 22 of those species are native to, and exotic within, Florida, respectively (*Oxalis* sp. is excluded from the latter two tallies; Table 2).

Marco Island is the largest island within the Ten Thousand Islands region and is situated 5.5 and 9.8 miles northwest of Dismal Key and Fakahatchee Island, respectively (as measured from the village of Goodland at the eastern edge of Marco Island). Thirty-five presently reported species were not previously documented for Marco Island, a location where Wilder and Roche (2009) had noted 470 infrageneric taxa (species, subspecies, varieties, and a hybrid). Twenty-four and 11 of the 35 species are native to, and exotic within, Florida, respectively (Table 2). Although, Marco Island shares many species with Dismal Key and Fakahatchee Island, it differs from the two islands, as follows: Marco Island is much larger than the other two islands, collectively; it is extensively developed; it exhibits dissimilar substrates (seven kinds of soils [Liudahl et al. 1998] and one small, highly disturbed shell mound); it manifests additional habitat types; and it connects via roads to the Florida mainland. Certain of those aspects have likely contributed to the floristic differences from Dismal Key and Fakahatchee Island.

Previous literature indicates that within shell-mound forests situated south of Tampa and Cape Canaveral, Florida " … white stopper [*Eugenia axillaris*], Florida swampprivet [*Forestiera segregata*], strangler fig [*Ficus aurea*], saffron plum [*Sideroxylon celastrinum*], and gumbo limbo [*Bursera simaruba*] are the most commonly encountered woody species" (Florida Natural Areas Inventory 2010). That conclusion matches present findings, i.e., all five species were common on Dismal Key and Fakahatchee Island.

Concluding Remarks

We suspect that the prehistoric Indian inhabitants of Dismal Key and Fakahatchee Island kept those islands clear of wild vegetation. Vegetation would have impeded foot travel, limited living space, obstructed visibility, and blocked canals. Furthermore, the Indians would not likely have tolerated the cacti and other armed species that pervade the islands today. We envision that plants migrated naturally onto the islands following the annihilation/departure of the Indians. Migration likely ensued at least 200 to 250 years ago, a conclusion that we base on Tebeau's (1965, 1968) statements that, by 1800, virtually all Calusa Indians had disappeared from South Florida, and on Marquardt's (2004) finding that "…the Calusa ceased to exist in Florida as a distinct society by 1750 …" The incoming plants likely originated from surrounding areas.

The Calusa Indians were a nonagricultural people. Never-the-less, they may have introduced and favored three species now present on one or both of the islands: *Carica papaya*, *Celtis iguanaea*, and *Gossypium hirsutum*. Each of these species has been utilized by primitive American peoples (Austin 2004; Ward 2011).

Certainly the island floras are less pristine today than they once were. As indicated, the non Indian inhabitants degraded native vegetation by building houses and other structures, by practicing farming, and by maintaining livestock; they also introduced nonagricultural exotics (Beriault et al 2003; Seely 2010). On each island, following habitation by non Indians the exotic species, particularly *Schinus terebinthifolia*, were partially eradicated by spraying herbicide, by clearing, and/or by burning (Beriault et al. 2003). Those activities were undertaken in order to diminish major threats to the diversity of native species on the Islands; however, they might have had unplanned short-term negative effects on the Island floras.

APPENDIX 1 [1]

List of species and higher-level taxa documented during the present study, together with additional data. [2] For certain species, listed after a species name is/are a relevant synonym (between brackets), an indication of whether the species is rare on Dismal Key and/or Fakahatchee Island, and/or the designation of the species by the Florida Exotic Plant Pest Council (FLEPPC). Individual species were observed either solely on Dismal Key, solely on Fakahatchee Island, or at both locations. Presented, beneath a species name, is/are the five-digit Wilder and McCombs [3] collection number(s) of voucher specimen(s) and habitat data for that species. Collection numbers in italics and in bold font represent the species from Dismal Key and Fakahatchee Island, respectively. For a species found on both islands, the habitat data presented are a summation of habitat data from both islands. After the name of each family and suprafamilial taxon, between parentheses are included two numbers which signify, respectively, the numbers reported presently of genera and species within that family or suprafamilial taxon. * = exotic in Florida [4]; ¤ = endemic to Florida; CHH = coastal hardwood hammock; FLEPPC I and FLEPPC II = taxa recognized as Category I or Category II species, respectively, by the Florida Exotic Plant Pest Council (2011); IT = insolated terrain; MANG = mangrove habitat; Rare DK = rare on Dismal Key; Rare DK, FI = rare on Dismal Key and Fakahatchee Island; Rare FI = rare on Fakahatchee Island; habitat with "c" signifies occurrence of a species in a small, overgrown cemetery on Fakahatchee Island, that was encircled by coastal hardwood hammock; habitat with "i" signifies occurrence of a species at the boundary between coastal hardwood hammock and insolated terrain; habitat with "ii" signifies occurrence of a species at the boundary between mangrove habitat and insolated terrain; habitat with "iii" signifies occurrence of a species at the boundary between coastal hardwood hammock and mangrove habitat.

PTERIDOPHYTES (3, 3)

Polypodiaceae (2, 2)
Phlebodium aureum (L.) J. Sm.; rare DK; *31186;* CHH^{i}
Pleopeltis polypodioides (L.) E.G. Andrews & Windham; rare DK, FI; *31717*, **31327;** CHH

Pteridaceae (1, 1)
Cheilanthes microphylla (Sw.) Sw.; *31246*, **30545**; CHH; IT

MONOCOTYLEDONS (23, 39)

Agavaceae (1, 2)
¤ *Agave decipiens* Baker; *30930*, **31889**; CHH; IT
Agave sisalana* Perrine; FLEPPC II; **31796; CHH; IT

Amaryllidaceae (1, 1)
Hymenocallis latifolia (Mill.) M. Roem.; *31250*, **31581**; CHH; IT

Asphodelaceae (1, 1)
Aloe vera* L.; **32233; IT

Bromeliaceae (1, 8)
Tillandsia balbisiana Schult. & Schult. f.; *31137*, **31599**; CHH; MANG; IT
Tillandsia fasciculata Sw.; *31208*, **30768**; CHH; MANG; IT
Tillandsia flexuosa Sw.; *31141*, **30652**; CHH; MANG; IT
Tillandsia paucifolia Baker; *31136*, **32882**; CHH; MANG; IT
Tillandsia recurvata (L.) L.; *31309*, **31979**; CHH; MANG; IT
Tillandsia setacea Sw.; *31880*, **31981**; CHH; MANG; IT
Tillandsia usneoides (L.) L.; *31191*, **30779**; CHH; *MANG; IT*
Tillandsia utriculata L.; *31252*, **30847**; CHH; MANG; IT

Commelinaceae (1, 1)
Commelina erecta L.; *31192*, **30821**; CHH; IT

Cyperaceae (2, 5)
Cyperus filiformis Sw. [*Cyperus floridanus* Britton ex Small]; *31715*, **30748**; CHH, CHH^{i}; IT
Cyperus ovatus Baldwin [*Cyperus retrorsus* Chapm.]; *31719*, **31707**; IT
Cyperus planifolius Rich.; *31544*, **30089**; MANG; IT
**Cyperus rotundus* L.; *32873*; IT

Fimbristylis cymosa R. Br.; _32175_, **31268**; IT

Orchidaceae (2, 2)
Encyclia tampensis (Lindl.) Small; _32012_, **31978**; CHH; MANG; IT
*_Oeceoclades maculata_ (Lindl.) Lindl.; rare DK, FI; _31546_, **31063**; CHH

Poaceae (13, 18)
*_Bothriochloa ischaemum_ (L.) Keng; Rare FI; **30839**; IT
*_Bothriochloa pertusa_ (L.) A. Camus; _32863_; IT
Cenchrus echinatus L.; Rare FI; **32865**; IT
*_Dactyloctenium aegyptium_ (L.) Willd. ex Asch. & Schweinf.; FLEPPC II; _31528_, **31576**; IT
Digitaria ciliaris (Retz.) Koeler var. _ciliaris_; Rare FI; **31700**; IT
*_Eragrostis ciliaris_ (L.) R. Br.; **30775**; CHH
Eustachys petraea (Sw.) Desv.; _31187_, **30747**; IT
*_Heteropogon contortus_ (L.) P. Beauv. ex Roem. & Schult.; Rare FI; **32866**; CHH
Lasiacis divaricata (L.) Hitchc.; **30038**; CHH
Leptochloa dubia (Kunth) Nees; _31718_, **31734**; IT
*_Melinis repens_ (Willd.) Zizka [_Rhynchelytrum repens_ (Willd.) C.E. Hubb.]; FLEPPC I; _31117_, **30843**; IT
Setaria chapmanii (Vasey) Pilg. [_Paspalidium chapmanii_ (Vasey) Davidse & R.W. Pohl]; _32870_, **31701**; IT
Setaria macrosperma (Scribn. & Merr.) K. Schum.; _31879_; IT
Sporobolus domingensis (Trin.) Kunth; _31184_, **31577**; IT
*_Sporobolus jacquemontii_ Kunth; _31190_; IT
Sporobolus pyramidatus (Lam.) Hitchc.; **32867**; IT
*_Urochloa distachya_ (L.) T.Q. Nguyen [_Urochloa subquadripara_ (Trin.) R.D. Webster]; Rare DK; _32872_; IT
*_Urochloa fusca_ (Sw.) B.F. Hansen & Wunderlin; _31529_, **30040**; IT

Ruscaceae (1, 1)
*_Sansevieria hyacinthoides_ (L.) Druce; FLEPPC II; **32247**; CHH; IT

DICOTYLEDONS (112, 130)

Acanthaceae (1, 1)
Dicliptera sexangularis (L.) Juss.; _31984_, **30824**; CHH, CHH[iii]; IT

Aizoaceae (1, 1)
Sesuvium portulacastrum (L.) L.; 31195, **31338**; MANG; IT

Amaranthaceae (4, 4)
Alternanthera flavescens Kunth; _31213_, **30850**; CHH; MANG; IT
Blutaparon vermiculare (L.) Mears; _31857_, **31277**; MANG; IT
Celosia nitida Vahl; **31745**; CHH
Iresine diffusa Humb. & Bonpl. ex Willd.; _31547_, **31986**; CHH; IT

Anacardiaceae (3, 3)
*_Mangifera indica_ L.; Rare FI; **32250**; CHH
*_Schinus terebinthifolia_ Raddi; FLEPPC I; _31746_, **31711**; CHH; MANG; IT
*_Spondias purpurea_ L.; Rare DK; _32093_, **31548**; CHH

Annonaceae (1, 1)
*_Annona squamosa_ L.; Rare DK; 32317; CHH[i]

Apocynaceae (2, 2)
*_Catharanthus roseus_ (L.) G. Don; Rare FI; **30749;** CHH[i]
Pentalinon luteum (L.) B.F. Hansen & Wunderlin; Rare DK, FI; _31530_, **31988**; IT

Asclepiadaceae (3, 3)
*_Cryptostegia grandiflora_ R. Br.; **32088**; CHH; IT
Cynanchum angustifolium Pers.; _32179_, **32129**; IT
Sarcostemma clausum (Jacq.) Roem. & Schult.;Rare DK; _31890_; IT

Asteraceae (9, 9)
Baccharis halimifolia L.; Rare DK; _31747_; IT
Bidens alba (L.) DC.; _31040_, **30851**; IT
Borrichia frutescens (L.) DC.; _31215_, **31583**; MANG; IT
Chromolaena odorata (L.) R.M. King & H. Rob.; **32014**; CHH; IT
Eupatorium capillifolium (Lam.) Small ex Porter & Britton; Rare DK, FI; _31216_, **30750**; CHH
Melanthera nivea (L.) Small; _31196_, **30852**; IT
Pectis glaucescens (Cass.) D.J. Keil; _32874_; IT
*_Sonchus oleraceus_ L.; Rare DK, FI; _31041_, **30935**
Verbesina virginica L.; _31721_, **32094**; CHH; IT

Avicenniaceae (1, 1)
Avicennia germinans (L.) L.; _31533_, **31339**; MANG

Bataceae (1, 1)
Batis maritima L.; _31042_, **32132**; MANG; IT

Bignoniaceae (1, 1)
*_Tecoma stans_ (L.) Juss. ex Kunth; **30090**; CHH; IT

Boraginaceae (2, 2)
Heliotropium angiospermum Murray; 31197, **30854**; CHH; IT
Tournefortia volubilis L.; **30057**; CHH

Brassicaceae (2, 2)
Cakile lanceolata (Willd.) O.E. Schulz; _32089_, **30757**; IT
Lepidium virginicum L.; _31212_, **30855**; IT

Burseraceae (1, 1)
Bursera simaruba (L.) Sarg.; _31122_, **30780**; CHH; IT

Cactaceae (3, 4)
Acanthocereus tetragonus (L.) Hummelinck [_Acanthocereus pentagonus_ (L.) Britt. & Rose]; _29857_, **31675**; CHH; MANG; IT
*_Cereus repandus_ (L.) Mill. [_Cereus peruvianus_ (L.) Mill.]; Rare FI; **32736**; CHH
Opuntia humifusa (Raf.) Raf.; **32299**; IT
Opuntia stricta (Haw.) Haw.; _29818_, **32300**; CHH; MANG; IT

Capparaceae (1, 2)
Capparis jamaicensis Jacq. [_Capparis cynophallophora_ L.]; _29703_, **31280**; CHH; MANG; IT
Capparis flexuosa (L.) L.; _29705_, **30828**; CHH; MANG; IT

Caricaceae (1, 1)
Carica papaya L.; _31862_, **30860**; CHH; IT

Celastraceae (1, 1)
Maytenus phyllanthoides Benth.; **32045**; MANG

Celtidaceae (1, 1)
Celtis iguanaea (Jacq.) Sarg.; Rare DK; _31921_; CHH

Chenopodiaceae (2, 2)
Atriplex pentandra (Jacq.) Standl. [_Atriplex cristata_ Humb. & Bonpl. ex Willd.; _31253_, **30461**; MANG; IT
Suaeda linearis (Elliott) Moq.; _31534_, **31589**; MANG

Combretaceae (2, 2)
Conocarpus erectus L.; _31722_, **31281**; CHH; MANG; IT
Laguncularia racemosa (L.) C.F. Gaertn.; _31254_, **31282**; MANG

Convolvulaceae (1, 5)
Ipomoea alba L.; Rare DK; 31863; MANG
Ipomoea hederifolia L.; **32875**; IT
Ipomoea indica (Burm.) Merr.; _31046_, **30937**; CHH; MANG; IT
*_Ipomoea triloba_ L.; _31748_, **31803**; MANG; IT
Ipomoea violacea L.; _32877_, **31749**; MANG[ii]

Crassulaceae (1, 3) [5]
*_Kalanchoe daigremontiana_ Raym.-Hamet & H. Perrier; **32015**; CHH; IT
*_Kalanchoe delagoensis_ Eckl. & Zeyh.; **32095**; CHH
*_Kalanchoe pinnata_ (Lam.) Pers.; FLEPPC II; **31989**; CHH
*_Kalanchoe_ sp. (sterile) [5]

Cucurbitaceae (1, 1)
Melothria pendula L.; 31047; CHH; IT

Euphorbiaceae (5, 6)
Acalypha ostryifolia Riddell ex J.M. Coult.; Rare FI; **30058**; CHH^{c}
Chamaesyce hypericifolia (L.) Millsp.; _31257_, **30758**; IT
Chamaesyce opthalmica (Pers.) D.G. Burch; _31258_, **30786**; CHH; IT
*_Euphorbia tirucalli_ L.; **30759**; CHH
*_Jatropha gossypifolia_ L.; **30938**; IT
Poinsettia cyathophora (Murray) Bartl.; _31198_, **30861**; CHH^{i}; IT

Fabaceae (13, 15)
Acacia tortuosa (L.) Willd.; 32260; IT
Caesalpinia bonduc (L.) Roxb.; _31867_, **31809**; CHH; MANG; MANG^{ii}
Canavalia rosea (Sw.) DC.; Rare DK, FI; _31536_, **32261**; MANG^{ii}; IT
*_Crotalaria incana_ L.; _31283_, **30867**; IT
Dalbergia ecastaphyllum (L.) Taub.; _32885_; CHH^{iii}
*Delonix _regia_ (Bojer ex Hook.) Raf.; Rare DK, FI; _32096_, **31284**; CHH^{i}; IT
Erythrina herbacea L.; _32563_, **30787**; CHH; IT
Galactia striata (Jacq.) Urb.; _32262_, **32098**; CHH; IT
*_Leucaena leucocephala_ (Lam.) de Wit; FLEPPC II; **31869**; CHH
Piscidia piscipula (L.) Sarg.; _31228_, **30788**; CHH; IT
Pithecellobium unguis-cati (L.) Benth.; _31900_, **30939**; CHH; IT
*_Senna atomaria_ (L.) H.S. Irwin & Barneby; _31267_; CHH; IT
Senna ligustrina (L.) H.S. Irwin & Barneby; _31752_, **32001**; CHH^{i}, CHH^{c}; IT
*_Senna obtusifolia_ (L.) H.S. Irwin & Barneby; _31753_, **32878**; IT
Sophora tomentosa var. _truncata_ Torr. & A. Gray; _31229_, **30868**; MANG; IT

Loasaceae (1, 1)
Mentzelia floridana Nutt. ex Torr. & A. Gray; _31200_, **32075**; CHH; IT

Malvaceae (5, 5)
Abutilon permolle (Willd.) Sweet; _29680_, **30796**; CHH; IT
Gossypium hirsutum L.; _31901_, **32053**; MANG; IT
Malvastrum corchorifolium (Desr.) Britton ex Small; Rare FI; _31261_, **32879**; IT
Sida antillensis Urb.[6]; _31262_, **32100**; CHH; IT
*Thespesia populnea (L.) Sol. ex Corrêa; Rare FI; FLEPPC I; **30762**; CHH^{i}

Moraceae (1, 1)
Ficus aurea Nutt.; _31238_, **31694**; CHH; IT

Myrsinaceae (1, 1)
Ardisia escallonioides Schiede & Deppe ex Schltdl. & Cham.; _31127_, **31916**; CHH

Myrtaceae (3, 4)
Eugenia axillaris (Sw.) Willd.; _29745_, **30801**; CHH; IT
Eugenia foetida Pers.; _31538_; CHH; IT
Myrcianthes fragrans (Sw.) McVaugh; _31239_, **31275**; CHH; IT
*_Psidium guajava_ L.; Rare FI; FLEPPC I; **32101**; CHH

Nyctaginaceae (2, 2)
Boerhavia diffusa L.; _31203_, **30763**; IT
Pisonia aculeata L.; _31129_, **30464**; CHH; MANG; IT

Oleaceae (1, 1)
Forestiera segregata (Jacq.) Krug & Urb.; _31990_, **30869**; CHH; IT

Oxalidaceae (1, 1)
Oxalis sp. (sterile); _32880_; CHH^{i}

Papaveraceae (1, 1)
Argemone mexicana L.; Rare FI; **30764**; IT

Passifloraceae (1, 1)
Passiflora suberosa L.; _31211_, **30870**; CHH; IT

Phytolaccaceae (2, 2)
Petiveria alliacea L.; 31539, **32103**; CHH
Rivina humilis L.; _31131_, **30871**; CHH; IT

Plumbaginaceae (1, 1)
Plumbago zeylanica L. [_Plumbago scandens_ L.]; _31871_, **31754**; CHH; IT

Polygonaceae (2, 3)
*_Antigonon leptopus_ Hook. & Arn.; FLEPPC II; _31204_, **31697**; CHH^{c}, CHH^{i}
Coccoloba diversifolia Jacq.; _32402_, **31872**; CHH; IT
Coccoloba uvifera (L.) L.; _31919_, **32268**; CHH; MANG^{ii}

Portulacaceae (1, 2)
Portulaca oleracea L.; _31205_, **30832**; IT
Portulaca rubricaulis Kunth; _31242_, **32694**; IT

Rhamnaceae (1, 1)
*_Colubrina asiatica_ (L.) Brongn.; Rare FI; FLEPPC I; **31810**; MANG^{ii}

Rhizophoraceae (1, 1)
Rhizophora mangle L.; _31541_, **31276**; MANG

Rubiaceae (4, 4)
Chiococca alba (L.) Hitchc.; _31264_, **31698**; CHH; IT
Morinda royoc L.; _29768_, **31287**; CHH; IT
Psychotria nervosa Sw.; _31133_, **30808**; CHH; IT
Randia aculeata L.; _32403_, **30809**; CHH; IT

Rutaceae (1, 1)
*_Citrus sp._; Rare DK; _31992_; CHH

Sapindaceae (3, 3)
Cardiospermum microcarpum Kunth.; _32196_, **31874**; CHH^{i}; IT
*_Dimocarpus longan_ Lour.; Rare DK; _31134_; IT
Sapindus saponaria L.; _31756_, **30469**; CHH; IT

Sapotaceae (3, 4)
Chrysophyllum oliviforme L.; _32576_, **32104**; CHH
*_Manilkara zapota_ (L.) P. Royen; Rare DK; FLEPPC I; _32881_, **31993**; CHH
Sideroxylon celastrinum (Kunth) T.D. Penn.; _31183_, **30833**; CHH; MANG; IT
Sideroxylon foetidissimum Jacq.; _31243_, **30470**; CHH; IT

Scrophulariaceae (1, 1)
Capraria biflora L.; _31050_, **30810**; CHH; IT

Solanaceae (4, 6)
Capsicum annuum L.; _31055_, **30471**; CHH; CHH^{i}; IT
Lycium carolinianum Walter; _31244_, **31289**; MANG
Physalis angulata L.; _31792_; IT
Physalis sp.[7]; Rare FI; **30872**; CHH
Solanum americanum Mill.; Rare FI; _31056_, **30874**; CHH; IT
*_Solanum lycopersicum_ L. [_Lycopersicon esculentum_ Mill.]; Rare FI; **30873**; CHH^{i}

Sterculiaceae (1, 1)
Waltheria indica L.; Rare FI; **30816**; IT

Surianaceae (1, 1)
Suriana maritima L.; Rare FI; **32883**; IT

Verbenaceae (2, 3)
*_Lantana camara_ L.; FLEPPC I; **32105**; CHH^{c}
Lantana involucrata L.; 32021, **31290**; CHH; IT
*_Stachytarpheta cayennensis_ (Rich.) Vahl; [_Stachytarpheta urticifolia_ Sims.]; FLEPPC II; _31920_, **30818**; CHH; IT

Vitaceae (2, 3)
Ampelopsis arborea (L.) Koehne; Rare FI; **32884**; CHH
Cissus trifoliata (L.) L.; _31542_, **30765**; CHH; IT
Cissus verticillata (L.) Nicolson & C.E. Jarvis; _31266_, **30766**; CHH; MANG^{ii}; IT

[1] We follow the nomenclature of Wunderlin and Hansen (2011), with four exceptions. (1) We recognize four families which they subsumed within other families. Between parentheses, after the name of each family that we recognize is listed the corresponding family in Wunderlin and Hansen (2011): Asclepiadaceae (Apocynaceae), Capparaceae (Brassicaceae), Chenopodiaceae (Amaranthaceae), and Sterculiaceae (Malvaceae). (2) We recognize varieties of *Digitaria ciliaris* (Retz.) Koeler, as did Wipff (2003). Wunderlin and Hansen (2011) did not do so. (3) We recognize *Setaria chapmanii* (Vasey) Pilg., as did Rominger (2003), whereas, Wunderlin and Hansen (2011) called this species *Paspalidium chapmanii* (Vasey) Davidse & R.W. Pohl. (4) We recognize *Sporobolus jacquemontii* Kunth, as did Peterson, Hatch, and Weakley (2003), whereas, Wunderlin and Hansen (2011) called this species *Sporobolus indicus* var. *pyramidalis* (P. Beauv.) Veldkamp.

[2] We lack habitat data for *Kalanchoe* sp. of Dismal Key and for *Sonchus oleraceus* on both islands.

[3] Ms. Martha McCombs contributed importantly to SWF; hence, on the label of each herbarium sheet George Wilder's name and Martha McCombs' name precede the collection number, a circumstance not duplicated in this Appendix.

[4] We follow Wunderlin and Hansen (2011) in designating whether species are native or exotic within Florida, with one exception, viz., *Carica papaya*. Wunderlin and Hansen (2011) deemed *C. papaya* as exotic within Florida. Ward (2011), however, considered this species native, based on certain previous workers' excavations of papaya seeds from a former Indian settlement in Lee Co., Florida, which were dated to "... no later than 300 A.D." We accept Ward's (2011) conclusion.

[5] *Kalanchoe* sp. might be equivalent to one of the other species of *Kalanchoe* reported here; hence, K. sp. is excluded from the summations of species of Crassulaceae and of dicotyledons.

[6] In accordance with Wunderlin and Hansen (2011), we recognize *Sida antillensis* Urb.; however, it appears likely that "...this is not a good species" and that it will probably be subsumed into *Sida ulmifolia* Mill. (Dr. Bruce Hansen, pers. comm. of Dec. 1, 2011).

[7] Although, we could not identify *Physalis* sp. to species (our material lacked flowers at anthesis), this species was not *Physalis angulata* L., a species also reported herein.

ACKNOWLEDGMENTS

We express deep appreciation to Brian Holley and the Naples Botanical Garden for providing laboratory space for the present study and for housing the Herbarium of Southwestern Florida. We also thank the following individuals and institutions for their assistance: John Beriault; Chris Brighton; Falon Cartwright; Christine Cook; Daniel Cox; Tony Donzello; Allison Duran; Richard Fagan; Eric Foht; Ernest Kerskie and the Office of the Collier County Property Appraiser; Mike Fraine; Susan Gallagher; Brian Galligan; David Graff; Peter Griffith; Sue Guinan; Wade Gurley, Joyce Mazourek, Larry Richardson and the United States Department of the Interior U.S. Fish and Wildlife Service; Brett Jastrow and the Fairchild Tropical Garden Herbarium; Bruce Hansen, Richard Wunderlin, and the Institute for Systematic Botany (University of South Florida); Erica Klopf; Sarah Larsen; Cyril Marks; William Marquardt; Bill McGreevy; Zachary Miller; Nathan Mitchell; Andrea Niccarato; Christina Ottman, Jill Schmid, and Victoria Vazquez and the Florida Department of Environmental Protection Rookery Bay National Estuarine Research Reserve; Betty Plum; Charles Ray; Mary Raymond; Karen Relish; Sally Richardson; Jean Roche; Jimi Sadle; Margo Schwadron; Bud Smith; Brenda Thomas; Mitch Thompson; Wendell Vaught; Taylor Walker; and Eileen Watkins. The detailed reviews of Richard Wunderlin and Jimi Sadle are much appreciated.

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NOTEWORTHY PLANT RECORDS FROM LOUISIANA

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ABSTRACT

Thirteen significant vascular plant records are reported herein. *Cyperus fuscus*, *Panicum bergii*, *Polygala brevifolia*, *Rhynchospora inundata*, *Veronica beccabunga*, and *Xyris smalliana* are confirmed as new state records. Four records are reported of *Lipocarpha micrantha*, which was previously regarded as historical in Louisiana. The second extant population of the federally-listed *Schwalbea americana* from Louisiana is documented. Recent specimens of *Eleocharis engelmannii*, *Eragrostis barrelieri*, *Fimbristylis schoenoides*, *Panicum hallii* var. *filipes*, and *Schoenoplectus etuberculatus* are regarded as noteworthy since there are few records of these taxa from Louisiana.

RESUMEN

Se aportan aquí trece citas significativas de plantas. *Cyperus fuscus*, *Panicum bergii*, *Polygala brevifolia*, *Rhynchospora inundata*, *Veronica beccabunga*, y *Xyris smalliana* se confirman como nuevas citas para el estado. Se hacen cuatro citas de *Lipocarpha micrantha*, que se tenía previamente como histórica en Louisiana. Se documenta la segunda población existente de *Schwalbea americana* en Louisiana presetne en el listad federal. Recientes especímenes de *Eleocharis engelmannii*, *Eragrostis barrelieri*, *Fimbristylis schoenoides*, *Panicum hallii* var. *filipes*, y *Schoenoplectus etuberculatus* se consideran notables ya que hay pocas citas de estos taxa en Louisiana.

INTRODUCTION

Recent floristic work in Louisiana has resulted in the discovery of new plant records and other significant collections (Reid & Faulkner 2006; MacRoberts et al. 2007; Reid et al. 2007; Reid et al. 2008; Reid and Faulkner 2010). In this paper we report six species new to Louisiana and noteworthy collections of seven additional taxa. Accounts of these records are presented alphabetically by family and scientific name.

CYPERACEAE

Cyperus fuscus L.

Tucker et al. (2002) report the distribution of this exotic sedge to include California, Connecticut, Maryland, Massachusetts, Missouri, Nebraska, Nevada, New Jersey, Pennsylvania, South Dakota, and Virginia in the United States, and Ontario and Quebec in Canada. It has since been discovered in Arkansas and Mississippi (Bryson & Carter 2010). The specimens cited below represent the first records of *C. fuscus* in Louisiana. Both are from the Mississippi River bank between Baton Rouge and New Orleans. McKenzie et al. (1998) and Bryson and Carter (2010) provide detailed information on its occurrence in North America and present ecological data and illustrations.

Voucher specimens: **Iberville Parish:** Mississippi River bank at LSU Sugar Cane Experiment Station, W of LA 75 ca. 1 km S of Sunshine; lat: 30.265441, long: -91.112060, uncommon on moist, sandy river bank with *Fimbristylis vahlii*, *Panicum capillare*, *Cyperus squarrosus*, *Eragrostis hypnoides*, *Panicum dichotomiflorum*, *Heliotropium procumbens*, etc., 17 Nov 2010, *Reid* 7783 w/*Urbatsch* (LSU, VSC). **St. Charles Parish:** Mississippi River bank below Bonne Carre Spillway control structure, ca. 2.4 air km W of Norco, lat: 29.999630, long: -90.442887, rare, ca. 12 plants observed, on open moist sandy substrate, with *Salix nigra* seedlings, *Leptochloa scabra*, *Mollugo verticillata*, *Panicum capillare*, *Fimbristylis vahlii*, *Leucospora multifida*, *Heliotropium procumbens*, and *Cyperus surinamensis*, 1 Dec 2010, *Reid* 7788 (LSU, SWSL).

Eleocharis engelmannii Steud.

This widespread spike sedge was reported new to Louisiana by Sorrie and Leblond (2008) based on a specimen

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collected in 1967 from Jefferson Davis Parish (*Thieret 27938*, DUKE). The De Soto Parish specimen cited below is apparently the second record of this species from Louisiana.

Voucher specimens: **De Soto Parish:** wet swale in relatively new pipeline ROW 0.4 km W of LA 175, ca. 1.6 km N of jct. with I-49 and ca. 2.8 km S of Frierson; lat/long: 32°13'54.1"N, 93°42'23" W, abundant in wet swale growing in several cm of water, with *Cyperus pseudovegetus*, *Glyceria declinata*, *Eleocharis obtusa*, *E. montana*, *Juncus* spp., 19 May 2009, *Reid 7028 w/Faulkner* (LSU, LSUS, TEX-LL, VSC, WIS).

Fimbristylis schoenoides (Retz.) Vahl

Thomas and Allen (1993) report this species for Louisiana based on a specimen collected from a roadside ditch in the vicinity of the community of Goodbee in St. Tammany Parish in 1960 (*Hebert 385*, LSU). The specimen cited below was collected ca. 3.5 km northeast of Goodbee and documents the continued existence of this exotic sedge in that area ca. 50 years after its original discovery.

Voucher specimens: **St. Tammany Parish:** Lake Ramsay Savannah WMA, S of Lake Ramsay Subdivision and Riverlake Road, E of oxidation ponds, ca. 5.5 air mi NW of Covington; lat/long: 30°31'25"N, 90°10'41"W, common along ATV trail leading S in wet swales, with weedy elements such as *Fimbristylis miliacea*, *F. tomentosa*, *Paspalum urvillei*, and *Steinchisma hians*, 8 Sep 2009, *Reid 7183 w/Jones* (ANHC, LSU, LSUS, TEX-LL, VDB, VSC), same locality, 13 Oct 2009, *Reid 7289* (ANHC, EIU, LSU, MO).

Lipocarpha micrantha (Vahl) G. Tucker

MacRoberts and MacRoberts (2006) report *Lipocarpha micrantha* from Caddo Parish in the extreme northwestern corner of the state based on a specimen collected in 1959 (*Shireman 56*, LSU) from the shoreline of Cross Lake. Lloyd and Tracy (1901) report *L. micrantha* from the bank of South Pass, which is part of the Mississippi River Delta in Plaquemines Parish. R.S. Cocks collected *L. micrantha* from "banks of the Mississippi River, New Orleans" near the turn of the 20th century (*Cocks s.n.*, NO). These records of *Lipocarpha micrantha* were the only ones known from Louisiana prior to 2010. Since the most recent of which is ca. 50 years old, the species was ranked as historical for Louisiana (NatureServe 2010). Specimens cited below from Iberville, Plaquemines, and St. Charles Parishes represent new occurrences discovered in 2010. The St. Mary Parish specimen, which came to light in early 2011, consists of several plants of *L. micrantha* incidentally collected and mixed with a sheet of *Cyperus surinamensis* Rottb. It appears this small annual sedge may be overlooked in Louisiana, rather than truly rare.

Voucher specimens: **Iberville Parish:** Sandy bank of the Mississippi River within 30 m of the main channel, ca. 2.25 km SE of the jct. of Bayou Paul Lane and LA 75 S of Sunshine, uncommon and growing in association with *Cyperus squarrosus*, *C. erythrorhizos*, *Eragrostis barrelieri*, *E. hypnoides*, *Fimbristylis vahlii*, *Leptochloa* spp., *Panicum capillare*, *P. dichotomiflorum*, and *Mollugo verticillata*, lat/long: 30.261975°N, 91.108812°W, elev. ca. 4 m, 9 Nov 2010, *Urbatsch 10019 w/Reid* (LSU). **Plaquemines Parish:** Delta National Wildlife Refuge, N of Pass a Loutre ca. 4 km E of Head of Passes, ca. 5.6 air km SE of Pilottown, lat/long: 29°09'10"N, 89°12'39"W, uncommon on sandy dredged material deposited 6–7 months prior, characteristic species included *Fimbristylis vahlii*, *Cyperus squarrosus*, *Panicum dichotomiflorum*, *Leptochloa* spp., *Eragrostis hypnoides*, *Panicum capillare*, and *Mollugo verticillata*, 30 Jul 2010, *Reid 7549 w/Victoriano* (LSU, NCU). **St. Charles Parish:** Mississippi River bank below Bonne Carre Spillway control structure, ca. 2.4 air km W of Norco, lat/long: 29°59'57"N, 90°26'13"W, common on recently deposited moist sand, with *Fimbristylis vahlii*, *Cyperus squarrosus*, *Salix nigra* seedlings, *Cyperus erythrorhizos*, *Lindernia dubia*, *Eragrostis hypnoides*, and *Leptochloa panicoides*, 19 Aug 2010, *Reid 7577* (LSU, NCU, SWSL, VSC). **St. Mary Parish:** North Beach on E side of Atchafalaya River, ca. 4.8 km downstream from jct. with Intracoastal Canal (as it heads W), ca. 8.8 km SSW of Berwick, lat/long: 29°37'28"N, 91°15'21"W, sandy, relatively high river bank, 5 Nov 2008, *Reid 6897 w/Lejeune* (LSU).

Rhynchospora inundata (Oakes) Fernald

Rhynchospora inundata is not reported as occurring in Louisiana by Thomas and Allen (1993). Louisiana is included in the range of *R. inundata* by Moore (1997) and Kral (2000), possibly on the basis of a specimen collected from St. Tammany Parish in 1978 (*Loyacana and Pravata s.n.*, VDB). This specimen is annotated by Moore as *R. inundata* while its duplicate at GA is annotated by Kral as *Rhynchospora careyana* Fernald. We viewed scanned images of these specimens. Well-developed rhizomes are present on both specimens. The spikelets are immature. Spikelets are dense relative to the characteristic open, sparsely populated inflorescence described for *R. inundata* by McMillan (2007). The specific locality is the community of Florenville, which is typified by wet flatwoods with conspicuous *Taxodium ascendens* Brongn. We suspect the specimens at GA and VDB are in fact *R. careyana*, which is very abundant in the vicinity of Florenville. However, we did not actually examine them. The specimens cited below unambiguously vouch for the presence of *R. inundata* in the Louisiana flora.

Voucher specimens: **Sabine Parish:** Devil's Lake, W side of gas line ROW, below big cutover sandhill 5.9 km N of LA 473 via gated private roads, ca. 5.5 km W of jct. w/LA 392, ca. 5.4 air km W of Hornbeck, lat/long: 31°19'52"N, 93°27'24"W, apparently natural lake of unknown origin fed by seepage from upper end, beavers present, plants growing in wet sandy substrate on lake shore and in floating vegetation mats in lake, 28 Jul 2009, *Reid 7130* (ANHC, LSU, TEX-LL, VDB); 13 Aug 2009, *Reid 7159 w/Allain and Moore* (LSU, VSC); 21 Sep 2009, *Reid 7226 w/Jones and Singhurst* (EIU, LSU).

Schoenoplectus etuberculatus (Steud) Soják

The record cited below is only the second extant population of *Schoenoplectus etuberculatus* known from Louisiana. Diggs et al. (2006) regard this species to be of conservation concern in Texas. The rarity rank assigned to *S. etuberculatus* by NatureServe (2010) is G3G4, indicating its potentially global rarity.

Voucher specimens: **Sabine Parish:** Devil's Lake, W side of gas line ROW, below big cutover sandhill 5.9 km N of LA 473 via gated private roads, ca. 5.5 km W of jct. w/LA 392, ca. 5.4 air km W of Hornbeck, lat/long: 31°19'52"N, 93°27'24"W, apparently natural lake of unknown origin fed by seepage from upper end, beavers present, emergent in 6–8 in of water in upper end of lake, with *Juncus repens* and *Nymphoides aquatica*, ca. 100–200 eventually fertile culms, 28 Jul 2009, *Reid 7133* (LSU); 21 Sep 2009, *Reid 7219 w/Jones and Singhurst* (LSU).

OROBANCHACEAE

Schwalbea americana L.

This specimen represents the second extant occurrence of this federally-listed, endangered plant in Louisiana (NatureServe 2010). This population is ca. 11 km northwest of the previously known population in Allen Parish.

Voucher specimen: **Beauregard Parish:** Cow Creek Savannah, W of Texas Eastern Road ca. 1.6 km S of US 190, 2.4 km W of Allen Parish line and ca. 8 km E of Ragley, ca. 35 plants seen (ca. 20 fertile) on lower edge of ridge above flatwoods pond, with *Rhexia alifanus, Eupatorium leucolepis, E. rotundifolium, Aletris aurea, Schizachyrium scoparium, Tragia smallii, Liatris spicata*, 1 Jun 2010, *Reid 7444 w/Bass and Daigle* (LSU).

POACEAE

Eragrostis barrelieri Daveau

This Old World native is found in disturbed areas and, in the United States, is most frequent in the southwest, with scattered southeastern occurrences (Peterson 2003). Allen et al. (2004) report *E. barrelieri* to occur in five Louisiana parishes: Calcasieu, Cameron, Lafayette, Lincoln, and Webster. The specimens cited below represent new parish records. Both specimens were collected along the Mississippi River below Baton Rouge.

Voucher specimens: **Iberville Parish:** Sandy bank of the Mississippi River within 30 m of the main channel, about 1.4 mi SE of the jct. of Bayou Paul Lane and LA 75 S of Sunshine, rare and growing in association with *Cyperus squarrosus*, C. erythrorhizos, Eragrostis *hypnoides*, *Fimbristylis vahlii, Leptochloa* spp., *Panicum capillare, P. dichotomiflorum*, and *Mollugo verticillata*, lat/long: 30.261975°N, 91.108812°W, elev. ca. 4 m, 9 Nov 2010, *Urbatsch 10014* (LSU). **St. Charles Parish:** Mississippi River bank below Bonne Carre Spillway control structure, ca. 2.4 air km W of Norco, lat/long: 29°59'57"N, 90°26'13"W, common on sparsely vegetated dry sand deposit, 19 Aug 2010, *Reid 7586* (ANHC, LSU, VSC).

Panicum bergii Arechav.

The specimen of *Panicum bergii* cited below is apparently the first from Louisiana as it is not reported for the state by Thomas and Allen (1993), Freckmann and Lelong (2003), Allen et al. (2004), or USDA, NRCS (2010). It is regarded as an exotic in the U.S. and native to South America by Gould (1975), Freckmann and Lelong (2003), Diggs et al. (2006), and USDA, NRCS (2010). Correll and Johnston (1970) suggest some of the material in Texas is native and that the distribution of the species is bicentric. Rosen (2007) treats *P. bergii* as a native amphitropical disjunct in his floristic inventory of a Texas coastal prairie remnant.

Voucher specimen: **Cameron Parish:** Sabine National Wildlife Refuge, Marceaux Island, ca. 1.6 air km E of Sabine Lake, 2.8 km N of Willow Bayou Canal and 0.8 km E of Gray's Ditch, along small access canal, lat/long: 29°54'10"N, 93°45'06"W, coastal prairie, 10 May 2005, *Reid 5532 w/Allain and Faulkner* (LSU, UWSP).

Panicum hallii Vasey var. **filipes** (Scribn.) Waller

Hitchcock (1950) reports this taxon to occur at Shreveport, Louisiana. This report accounts for the inclusion of *P. hallii* var. *filipes* in Caddo Parish by Allen et al. (2004). Allen et al. (2004) also cite a specimen from Webster Parish (*Jeansonne s.n.*, LTU), collected from a nursery in Sibley, Louisiana. The *P. hallii* var. *filipes* record presented below is apparently only the third from Louisiana and is the first for which the associated natural community is known.

Voucher specimen: **De Soto Parish:** Dickson Prairie, N of LA 3276 via Missile Base and Brown Roads 2.4 km E of jct. w/US 171 in Stonewall, ca. 3.2 air km NE of Stonewall, lat/long: 32°18'28"N, 93°48'23"W, locally abundant in high quality saline prairie with *Aristida longespica*, *A. oligantha*, *Sporobolus vaginiflorus*, *Phemeranthus parviflorus*, and *Opuntia* sp., 10 Oct 2009, *Reid s.n. w/Dickson* (LSU, UWSP).

POLYGALACEAE

Polygala brevifolia Nutt.

Polygala brevifolia is not included in the Louisiana Flora by Thomas and Allen (1998) or Allen (1997); thus, it is reported as new to Louisiana on the basis of the specimen cited below. This record extends the known range of the species slightly to the west as it is known from adjacent Hancock County, Mississippi (USDA, NRCS 2010).

Voucher specimen: **St. Tammany Parish:** Abita Flatwoods Preserve, W of Jack Lloyd Road near its terminus, N of jct. w/LA 435, 9.3 km E of jct. w/LA 59 in Abita Springs, lat/long: 30°31'25"N, 89°57'38"W, common on small hammocks (e.g., tree bases) at interface of bayhead swamp and flat lower seepage slope bog, with *Pinus elliottii*, *Nyssa biflora*, *Sarracenia alata*, *Leucothoe axillaris*, *Persea palustris*, *Andropogon mohrii*, 8 Sep 2009, *Reid 7192 w/Jones* (LSU).

SCROPHULARIACEAE

Veronica beccabunga L.

Veronica beccabunga L. is reported for the first time to occur in Louisiana. Introductions of this European native have been reported from locations scattered from Illinois eastward to Maryland, West Virginia, and possibly Virginia northward into Canada, and also for a few of counties in California and Nevada (USDA, NRCS 2010; Weakley 2010). It has been reported from ca. one-half the counties in Michigan. Its documentation in Louisiana represents range extensions of well over 1100 km from Ohio and West Virginia and over 2700 km from California and Nevada (USDA, PLANTS 2010). The Louisiana location is from the Wax Lake Delta and is accessible only by boat. It was collected as part of the Coastwide Reference Monitoring System (CRMS) project of the Louisiana Department of Natural Resources.

Voucher specimen: **St. Mary Parish:** Wax Lake Delta area, Louisiana Department of Natural Resources monitoring station CRMS 0484, ca. 34 air km SW of Morgan City, with *Alternanthera philoxeroides*, *Eichhornia crassipes*, *Ludwigia palustris*, *Potamogeton nodosus*, *Sagittaria platyphylla*, lat/long: 29.49099°N, 91.4475175°W, elev. = sea level, 22 Jul 2009, *Dufrene and Viola s.n.* (LSU).

XYRIDACEAE

Xyris smalliana Nash

Xyris smalliana was included in the Louisiana Flora by MacRoberts (1984), then excluded by Thomas and Allen (1993). Voucher specimens supporting the inclusion of Louisiana in the range of *Xyris smalliana* by Kral (2000) are unknown to us. Therefore the specimens cited below confirm the presence of *X. smalliana* in Louisiana.

Voucher specimens: **Beauregard Parish:** ATV trail leading S from Pettifield Road near its jct. w/Camp Edgewood Road, ca. 5.1 km E of jct. w/LA 12 on E edge of DeQuincey, lat/long: 30°26'03"N, 93°21'31"W, locally common in wallowed out part of ATV trail, with *Gratiola brevifolia*, *Eleocharis microcarpa*, *Xyris laxifolia* var. *iridifolia*, *X. stricta* var. *obscura*, *Nyssa biflora*, and *Dichanthelium scabriusculum*, 15 Sep 2010, *Reid 7652 w/Bass* (LSU, NCU, VDB); E of Dickerson Road 1.6 km S of jct. w/Camp Edgewood Road, 3.8 km E of jct. w/LA 12 on E edge of DeQuincey, lat: 30.436970, long: -93.369236, abundant in impounded marsh dominated by *Eleocharis equisetoides*, organic substrate, 18 Oct 2010, *Reid 7729* (LSU, NCU, VDB).

ACKNOWLEDGMENTS

George and Gordon Dickson allowed field surveys of Dickson Prairie in northwest Louisiana where we discovered *Panicum hallii* var. *filipes*. Charles Bryson (SWSL) made us aware of the possibility of *Cyperus fuscus* occurring in Louisiana and kindly provided specimens of this taxon from Mississippi. We appreciate Jason Singhurst of Texas Parks and Wildlife for showing Reid several populations of *Xyris smalliana* in southeast Texas, which greatly helped in developing a search image for the species and increased the efficiency of finding it in Louisiana. Robert Freckmann (UWSP) kindly provided determinations of *Dichanthelium* and *Panicum*. Robert Kral (VDB) kindly provided verifications of *Xyris smalliana* and *Rhynchospora inundata*. We appreciate staff at GA and VDB for providing images of *Rhynchospora* specimens. Christopher Brantley of U.S. Army Corps of Engineers facilitated access to Bonne Carre Spillway where we discovered populations of *Cyperus fuscus*, *Eragrostis barrelieri*, and *Lipocarpha micrantha*. We thank Nelwyn McInnis and Latimore Smith of The Nature Conservancy for allowing access to Abita Flatwoods Preserve where we collected *Polygala brevifolia*. We are indebted to Barry Cook and Terry Dowden of Hancock Forest Management for allowing our surveys of Devil's Lake where we discovered *Rhynchospora inundata* and *Schoenoplectus etuberculatus*. We thank D.C. Albach, Institute of Botany, University of Vienna, for identifying *Veronica*. We express our gratitude to David Daigle for allowing our access to several properties he manages, including Cow Creek Savannah, where we discovered *Schwalbea americana*. We commend his excellent management of this and other ecologically important sites. Reid would like to express his appreciation for his employer, Louisiana Department of Wildlife and Fisheries, for providing the support necessary to conduct effective fieldwork and for paying the cost of this and other publications. Department of Biological Sciences, Louisiana State University also supported various aspects of this work. We appreciate the constructive reviews of Richard Carter and an anonymous reviewer.

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FURTHER ADDITIONS AND EMENDATIONS TO THE VASCULAR FLORA OF CADDO PARISH, LOUISIANA

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ABSTRACT

The vascular flora of Caddo Parish, Louisiana, is updated. Field and herbarium research has yielded 18 species new to the parish. The total parish count is now 1441 species, of which 16.8% are non-natives.

RESUMEN

Se pone al día la flora vascular de Caddo Parish, Louisiana. Las investigaciones de campo y herbario han dado como resultado 18 especies nuevas para la parroquia. En total se conocen actualmente 1441 especies, de las que el 16.8% no son nativas.

INTRODUCTION

Since the publication of our "An updated, annotated vascular flora of Caddo Parish, Louisiana, with notes on regional phytogeography and ecology" in 2006, "Noteworthy vascular plant collections from northwest Louisiana" in 2008, and "Additions and emendations to the vascular flora of Caddo Parish, Louisiana" in 2009, plant collecting in Caddo Parish has continued and species new to the parish have been found or located in herbaria. Eighteen additions and one deletion are given below. A nomenclatural problem is also discussed. An asterisk * indicates a non-native.

ADDITIONS TO THE CADDO PARISH FLORA

ASTERACEAE

Packera tomentosa (Michx.) C. Jeffrey, *Reid 6019* LSU. Sandy soil along oil/gas road in Caddo Black Bayou Preserve.

Solidago caesia L., *Salmon 311* LSUS. Pine-oak-hickory slope forest in Eddie D. Jones Park.

CAPRIFOLIACEAE

Viburnum dentatum L., *Salmon 193* LSUS. Wooded upland area of Eddie D. Jones Park. This species had previously been reported by Overby (1974), MacRoberts (1979), and Thomas and Allen (1996), from a specimen collected by R. Dale Thomas at NLU but we were unable to locate a voucher. Another search in 2012 by Dennis Bell at NLU failed to locate it.

CYPERACEAE

Carex bulbostylis Mackenzie, *Reid 7974* LSU. Red River National Wildlife Refuge in moist reddish substrate on edge of floodplain forest. In Caddo Parish, although on east side of the Red River.

Carex floridana Schwein., *Reid 3479* LSUS. Caddo Black Bayou Preserve. Sandhill woodland in mesic sand adjacent to blackwater stream alluvium in partial shade.

Dulichium arundinaceum (L.) Britt., *McFarlin s.n.* LSU. This was collected in 1923 on Tar Island, Caddo Lake. The label is ambiguous as to whether this was in Louisiana or Texas. We include it here as most of Tar Island is in Caddo Parish.

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Eleocharis baldwinii (Torr.) Chapm., *Reid 5975* LSU. Common on small islands exposed by low water, upper end of Black Bayou Lake.

Eleocharis lanceolata Fern., *Reid 7214* LSUS. Beside James Bayou in open moist disturbed sand.

Eleocharis quadrangulata (Michx.) Roemer & J.A. Schultes, *MacRoberts & MacRoberts 8882* LSUS. Wet area in saline prairie.

FABACEAE

Desmanthus virgatus (L.) Willd., *MacRoberts & MacRoberts 8919* LSU, LSUS. Waste ground in Shreveport (MacRoberts & MacRoberts 2011b).

Desmodium pauciflorum (Nutt.) DC., *Salmon 289* LSUS. Bottomland woodland in Eddie D. Jones Park.

JUNCACEAE

Luzula echinata (Small) F.J. Herm., *Salmon 341* LSUS. Pine-oak-hickory slope forest; Eddie D. Jones Park. This was previously reported by Thomas and Allen (1993) but we were unable to locate a voucher. It is not reported by MacRoberts (1979, 1989) or Overby (1973). A search by Anne Bradburn at NO located a specimen collected by Penfound s.n. in 1936 "Ravines, Greenwood, Louisiana."

LIMNOCHARITACEAE

**Hydrocleys nymphoides* (Humb. & Bonpl. ex. Willd.) Buch., *MacRoberts & MacRoberts 8660, 8670* LSU, LSUS. Wet ditch in Columbia Park, Shreveport (MacRoberts & MacRoberts 2010).

POACEAE

Coelorachis rugosa (Nutt.) Nash, *Reid 7208* LSU, LSUS. Margins of backwater lakes.

Panicum hallii Vasey, *Hitchcock* US-742164. Collection made in Shreveport in 1903; exact location or habitat not specified.

POLEMONIACEAE

Phlox subulata L., *Karen Luke s.n.* LSU. Sandy pineland near Shreveport.

SCROPHULARIACEAE

Mecardonia procumbens (P. Mill.) Small, *MacRoberts & MacRoberts 8897* LSUS. Wet ditch in Columbia Park, Shreveport.

SOLANACEAE

Physalis virginiana P. Mill., *MacRoberts & MacRoberts 187* LSU, *Pridgeon 31* LSU. Pine-hardwood woods. This had previously been reported for Caddo by Thomas and Allen (1998), but we were unable to find a specimen and thus did not include it on our checklist. Their report was based on the *MacRoberts & MacRoberts 187* specimen. We can now confirm that it occurs in Caddo Parish.

ZYGOPHYLLACEAE

Kallstroemia parviflora Norton, *MacRoberts & MacRoberts 8900, 8901, 8903, 8904, 8916, 8917c,* LSU, LSUS. Common in disturbed (frequently mowed) roadside along southern extension of Clyde E. Fant Memorial Parkway (MacRoberts & MacRoberts 2011a), on Fern Avenue right-of-way south of 70th Street, and in C. Bickham-Dickson/Red River Education and Research Park.

EMENDATIONS

What we have been calling *Thelesperma filifolium* (Hook.) A. Gray from xeric sandyland communities is *Thelesperma flavodiscum* (Shinners) B.L. Turner (see Turner 2007, 2010; Strother, 2006).

We previously misidentified *Galium obtusum* Bigelow; it is *Galium tinctorium* (L.) Scop. *Galium obtusum* should be deleted from the list.

DISCUSSION

The Caddo Parish vascular plant count now stands at 1441, of which 16.8 % are non-native. By any standard, Caddo Parish is well collected and exceeds predicted species richness (Williams & Lutterschmidt 2006; Williams & Debilica 2008; see also Kartesz 2011).

ACKNOWLEDGMENTS

Billie L. Turner confirmed our identification of *Desmanthus virgatus*. Charles Bryson and A. Reznicek aided with identification of the Cyperaceae. Thanks are due Katherine Rankin and Paul Peterson at US for tracing Hitchcock's *Panicum hallii* specimen. Anne Bradburn, NO, found the Penfound *Luzula echinata* specimen. Dennis Bell (NLU) and Charles Allen reviewed the paper and aided with plant searches.

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BOOK REVIEW

WERNER DRESSENDORFER. 2010. **Album Vilmorin: The Vegetable Garden.** (ISBN: 978-3836517775). Taschen, Hohenzollernring 53, D-50672 Köln, Germany. (**Orders:** www.taschen.com). $99.99, 34 pp., 46 plates, each 13.5" × 19.25", box measures 16.5" × 22".

From the publisher: "The Vilmorins, though only producers and merchants on the Paris market, contributed enormously to the botanical and agronomic knowledge of their time. Their first catalogue, comprising all kinds of seeds for kitchen-garden vegetables—including legumes, salad plants, flower seeds and bulbs, appeared in 1766. It was followed by a series of *Publications périodiques* in which the quality of botanical and horticultural information was equaled only by the illustrations. By the mid-19th century, the firm had become the most important seed company in the world … The company published its splendid *Album Vilmorin. Les Plantes potagères* (The Vegetable Garden, 1850–1895) featuring 46 magnificent color plates. … These illustrations—reproduced here with exquisite care and accuracy—transcend mere artistic interest, beautiful as they are; they are also a valuable resource for anyone researching cultivarietal evolution, and old varieties of fruits and vegetables."

These reproductions are beautiful, rich in color, and are presented in a very pleasing manner. This loose leaf box collection features simply beautiful illustrations, printed on deckle-edge, high-quality paper. The color and print quality are excellent. The box is very nicely executed and a lovely thirty-four page booklet accompanies the set. It is printed in English, French, and German and includes illustrations not reproduced in the plates. There is an index to the plates and a bibliography. Taschen is to be commended for continuing to produce such high quality reproductions at a price nearly anyone could afford.

If you like botanical art, this collection is for you. Each print is certainly frame-worthy. Recommended for academic libraries and those specializing in botany or agriculture.

—Gary L. Jennings, Librarian,
Botanical Research Institute of Texas, 1700 University Drive, Fort Worth, Texas 76107-3400, U.S.A.

BOOKS RECEIVED/REVIEWS FORTHCOMING

TIMOTHY P. SPIRA. 2011. **Wildflowers & Plant Communities of the Southern Appalachian Mountains & Piedmont: A Naturalist's Guide to the Carolinas, Virginia, Tennessee, & Georgia.** (ISBN: 978-0-8078-7172-0, pbk.). The University of North Carolina Press, 116 South Boundary St., Chapel Hill, North Carolina 27514-380, U.S.A. (**Orders:** www.uncpress.unc.edu). $26.00, 521 pp., color throughout, 6" × 9".

TIMOTHY A. BLOCK AND ANN FOWLER RHOADS. ILLUSTRATIONS BY ANNA ANISKO. 2011. **Aquatic Plants of Pennsylvania: A Complete Reference Guide.** (ISBN: 978-0-8122-4306-2, hbk.). University of Pennsylvania Press, 3905 Spruce St., Philadelphia, Pennsylvania 19104-4112, U.S.A. (**Orders:** www.upenn.edu/pennpress). $59.95, 308 pp., line drawings, distribution maps, color phots, 7" × 10".

ROBERT H. MOHLENBROCK. 2010. **Aquatic and Standing Water Plants of the Central Midwest. Nelumbonaceae to Vitaceae: Water Lotuses to Grapes.** (ISBN: 978-0-0893-2904-0, hbk.). Southern Illinois University Press, 1915 University Press Dr., SIUC Mail Code 6806, Carbondale, Illinois, 62901, U.S.A. (**Orders:** www.siupress.com/, custserv@press.uchicago.edu). $67.00, 465 pp., 346 line drawings, 6" × 9".

DISCOVERY OF *HYDROCOTYLE BOWLESIOIDES* (ARALIACEAE) IN LOUISIANA

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ABSTRACT

Hydrocotyle bowlesioides is reported for the first time for Louisiana. The report represents only the third report of the species for the continental United States. The species is contrasted with the morphologically similar *Bowlesia incana* to facilitate future detection.

RESUMEN

Se cita por primera vez *Hydrocotyle bowlesioides* para Louisiana. Esta cita es la tercera de la especie en la parte continental de Estados Unidos. Se contrasta la especie con *Bowlesia incana* que es similar morfológicamente para facilitar futuras detecciones.

This is the first report of *Hydrocotyle bowlesioides* Mathias & Constance (Araliaceae) for Louisiana and only the third report of the species for the continental United States. The report is based on a gathering in western Louisiana in 2004 and originally annotated as *Bowlesia incana* Ruiz & Pav. (Apiaceae). However, when reviewed by the present authors as part of a treatment of *Bowlesia* Ruiz & Pav. for the *Flora of North America*, it became evident that the specimens belonged instead to *Hydrocotyle* L. Preliminary investigation suggested *Hydrocotyle bowlesioides*, a hypothesis confirmed by close scrutiny of the protologue (Mathias & Constance 1942) and an assessment of high resolution digital images through jstor.plants.org of the type *Skutch 3573* (HT: US!; IT: K!, NY!). Native to Costa Rica and Panama, *Hydrocotyle bowlesioides* has been reported in the continental United States from Thomasville, GA (Anderson 1983) and Tallahassee, FL (Anderson 2007; see Mast et al. 2004 [continuously updated] for digital images of the specimens). Though only approximately thirty miles apart, these two populations likely resulted from different invasion events. As noted by Anderson (2007), the Thomasville population expired by the mid-1990s while the Tallahassee population, collected in 2006, occupies a site at which extensive construction and landscaping occurred in 2003 (L.C. Anderson, pers. comm.). The collection of *H. bowlesioides* in western Louisiana thus seems to represent a third instance of invasion in the southeastern United States, 500 miles west of the previously known introductions. Though the means of transport of the species remains obscure, its presence in Alabama, Mississippi, and eastern Texas may be expected.

Unfortunately, habitat details are absent from the collection labels of the Louisiana specimen. However, the presence of *Dichondra carolinensis* Michx. (Convolvulaceae) and a few leaves of a *Vicia* sp. (Fabaceae) intermixed with the *Hydrocotyle* on one of the duplicate sheets suggest a moist disturbed habitat, likely a lawn. Such a speculation is consistent with the habitats of both previously-reported populations.

As its epithet indicates, *H. bowlesioides* is superficially similar to some members of *Bowlesia*, including *Bowlesia incana*, the only representative of the genus in the southeastern United States. Like *H. bowlesioides*, *B. incana* is a non-native, low-growing weed found in lawns and other wet, often disturbed sites. Both species have palmately-lobed leaves that are pubescent on both surfaces and are borne on slender petioles that can be up to 12 cm long. However, the two species may be easily distinguished by the character and distribution of the trichomes, the number and shape of the leaf lobes, the character of the leaf margins, and various features of the fruits, as summarized in Table 1 and depicted in Figure 1.

Voucher specimen: LOUISIANA. Vernon Parish: private property W of La 399 circa 1.8 mi S of Cravens Sec 26 T1S R7W; 26 Apr 2004, *Charles Allen 19339* (BRIT [2 sheets]!).

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Table 1. Distinguishing morphological features between *Bowlesia incana* and *Hydrocotyle bowlesioides*.

	Bowlesia incana	*Hydrocotyle bowlesioides*
Trichomes	*stellate* (with (6–)8(–12) rays emanating from a central disk); not noticeably crowded at the apical portion of the petiole	*hirsute* (stiff, uniseriate); frequently crowded at and giving a fuzzy appearance to the apical portion of the petiole
Leaf lobes	5–9, oblong to elliptic, extending to near or just below the middle of the blade	5, obtusely triangular, shallow
Leaf margins	entire	crenate to nearly entire
Fruits	inflated (at least at maturity), stellate-pubescent to glabrous, ribs not prominent	not inflated, hispidulous, not stellate-pubescent, ribs prominent

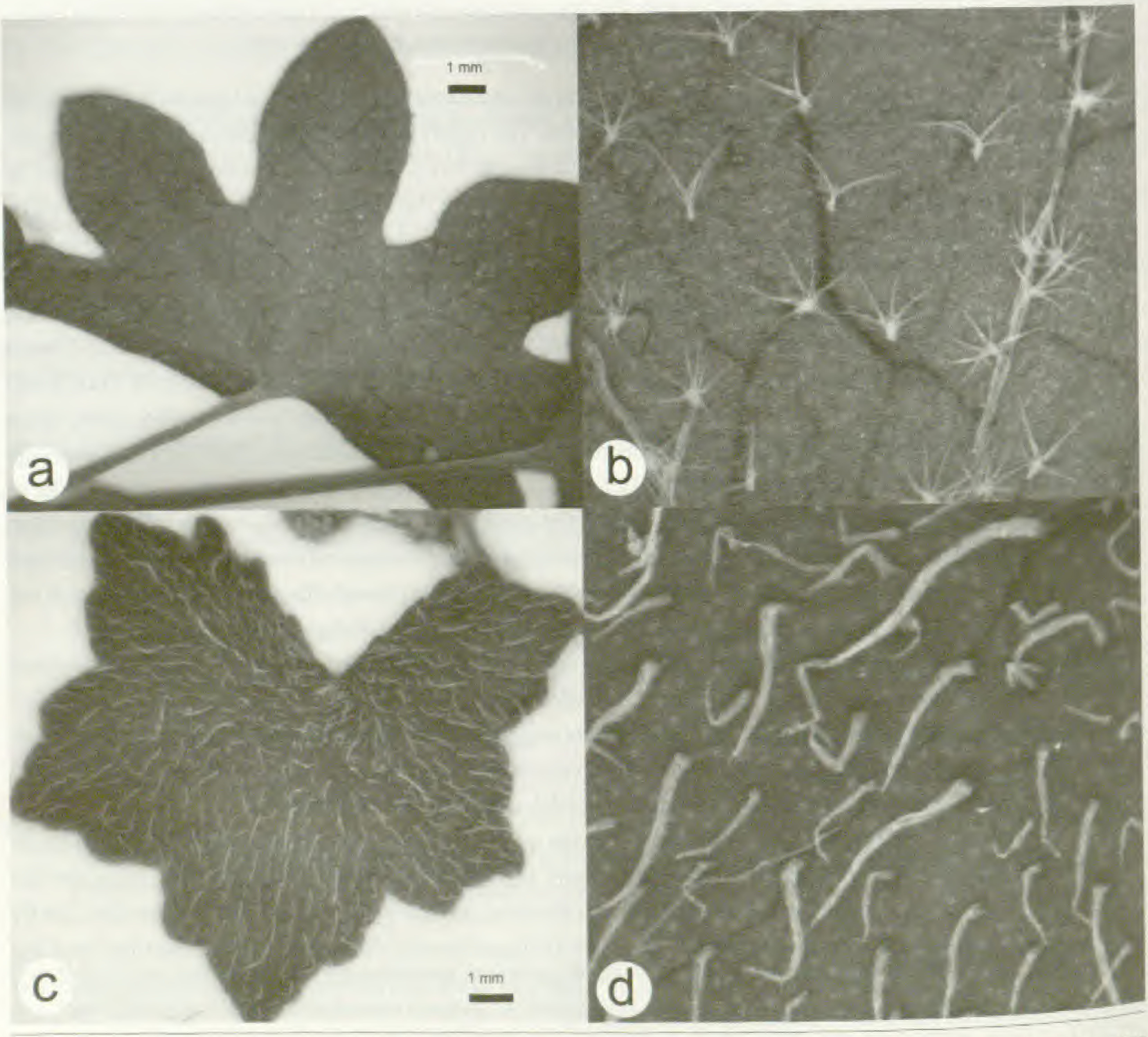

Fig. 1. Leaf and trichome morphology of *Bowlesia incana* (a–b) and *Hydrocotyle bowlesioides* (c–d). Based on *Sundell 18378* (BRIT; a–b) and *Allen 19339* (BRIT; c–d).

ACKNOWLEDGMENTS

We thank Loran C. Anderson (FSU) for sharing his insights about the Florida and Georgia populations of *H. bowlesioides*, and the following herbaria for making available specimen loans: ARIZ, AUA, BRIT, CAS, DES, FLAS, GA, LL, LSU, MISS, MISSA, NMC, NO, OKL, ORE, OSC, RENO, RSA, TEX, UNLV, UNA, UNM, USCH, VDB, WTU. We thank FSU for making available digital images of Florida collections (see Mast et al. in Literature Cited). Reviewers Michael MacRoberts, Ray Neyland, and Sam Kieschnick offered suggestions for improvement.

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MATHIAS, M.E. AND L. CONSTANCE. 1942. New North American Umbelliferae. Bull. Torrey Bot. Club 69:151–155.

BOOK REVIEW

Steve Huddleston and Pamela Crawford. 2009. **Easy Gardens for North Central Texas.** (ISBN: 978-0971222083, pbk.). Easy Color Publishing, 1353 Riverstone Parkway, Suite 120-372, Canton, Georgia 30114, U.S.A. (**Orders:** www.colorgardenpublishing.com, 561-371-2719). $24.95, 312 pp., color throughout, 8.5" × 11".

From the Publisher: "This groundbreaking book shows beginners and experienced gardeners alike how to create gorgeous gardens with the easiest, colorful, low water plants that north central Texas has to offer. It features over 1000 spectacular photos of annuals, perennials, shrubs, and trees that thrive with little or no irrigation and only require minutes of care per year—plants that can breeze through hot, humid, Texas summers while attracting butterflies, birds and hummingbirds. Shop for plants like a pro by taking the book with you to garden centers and checking out the latest information on the newest plants around from people who have grown them! Create traffic-stopping color combinations from the over 150 easy examples shown. The book is extremely easy to follow, with thousands of color photographs, as well as many budget gardening tips. For Dallas/Fort Worth and 50 surrounding counties."

Written by the Senior Horticulturist at the Fort Worth Botanic Garden, this book is nothing short of amazing and impressive. It is wonderful about stating the origin of each plant and went into much more detail about the plants than any book or gardening place could tell you. More than that, the pictures alone are worth the price. They show you which plants work well in Texas with few disease or pest issues, and also those that work well together. Every page concerning a specific plant has amazing close-ups of the plant and extreme detail on its maintenance, how to get cuttings to create new plants, and what to do in the winter to keep it going. However, these instructions are not long, wordy, pages but easy bullet points for simple use.

The book is divided into 5 sections: the basics, annuals, perennials, shrubs and vines, and trees. Within every section there is a two page spread for each flower/plant type they are describing (with great identifying photos). The book advises on plant habitat (U.S. zone, type of soil, & amount of light), how often to water, common pest problems, and treatment methods. It also describes when to plant, when to prune and fertilize. For a novice, it is an excellent resource and great for those who want to do it themselves.

If you are debating between Neil Sperry's book and this book, I would recommend this one. Everything you need to know about any particular plant is right there on a two page spread. You don't have to hunt around the book. Neil Sperry's book probably has more types of plants in it but the descriptions and care information are more detailed and easier to follow in this book. The only criticism I have is that I am afraid that the binding of the book will not withstand repeated usage. A lay-flat binding would have been much preferred by this reader.

I highly recommend this book to anyone who wants to do their own gardening but isn't sure how to go about it. With this book, I don't think you can go wrong.

—*Gary L. Jennings, Librarian,*
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BOOKS RECEIVED/REVIEWS FORTHCOMING

Susan M. Galatowitsch. 2012. **Ecological Restoration.** (ISBN: 978-0-87893-607-6, hbk.). Sinauer Associates, 23 Plumtree Road, Sunderland, Massachusetts 01375, U.S.A. (**Orders:** www.sinauer.com). $89.95, 630 pp., color figures, graphs, tables, 7.25" × 9.25".

AN ANNOTATED CHECKLIST OF THE MYXOMYCETES OF THE BIG THICKET NATIONAL PRESERVE, TEXAS

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ABSTRACT

The first checklist of the myxomycetes (plasmodial slime molds) of the Big Thicket National Preserve is presented herein. Eighty-eight species are listed. Fifty-three of the species listed are new records for the Preserve of which six are new records for Texas. One of the species new to Texas and the Preserve (*Arcyria margino-undulata*) is considered to be rare. Three other species (*Craterium paraguayense*, *Physarella oblonga*, and *Physarum bogoriense*) are recorded more often from subtropical and tropical than temperate habitats.

RESUMEN

Se presenta el primer catálogo de myxomycetes de la Big Thicket National Preserve. Se listan ochenta y ocho especies. Cincuenta y tres de las especies listadas son citas nuevas para la Reserva y de ellas seis son citas nuevas para Texas. Una de las especies nueva para Texas y la Reserva (*Arcyria margino-undulata*) se considera rara. Otras tres especies (*Craterium paraguayense*, *Physarella oblonga*, y *Physarum bogoriense*) se colectan más a menudo en hábitats subtropicales y tropicales que en templados.

INTRODUCTION

The myxomycetes are small, eukaryotic amoeboid organisms with trophic stages that feed upon populations of bacteria and other microorganisms associated with decaying plant material in all types of terrestrial habitats. There are approximately 900 species of myxomycetes known worldwide (Lado 2001). As a group, many species of myxomycetes are considered cosmopolitan, occurring across the globe in a variety of habitats. However, studies of their biodiversity and distribution suggest that species of myxomycetes are unevenly distributed across terrestrial habitats, with some possible habitat preferences observed for particular species (Stephenson et al. 2008).

The first reference in the literature to myxomycetes in the Big Thicket region was in the biological survey of the region by Parks and Cory (1936) in which the authors commented on the beauty of these organisms in the Big Thicket forests but included no species data. The published information relating to myxomycete diversity in the Big Thicket prior to the checklist presented in this paper is derived from surveys that predate the formation of the Preserve in 1974. None of these specifically targeted the Big Thicket region or East Texas. A herbarium and archive of specimen data survive for one statewide survey of myxomycetes (McGraw 1968). From the collecting localities recorded for each specimen, it was possible to develop a list of species for the area of the Big Thicket. Moreover, Alexopoulos and Henney (1971) specifically mentioned the Big Thicket area in his annotations for some species. It is not possible to determine if the localities from either survey are within what is now the Big Thicket National Preserve, but it is assumed that they fall within the biological Big Thicket region. While no previous survey of myxomycetes specifically targeted the Big Thicket region, it should be noted that much of what is known about the myxomycetes of the state of Texas as a whole was derived from the work of C.J. Alexopoulos and his students while the former was a member of the faculty at the University of Texas. His studies set the stage for both the research reported herein and other similar research efforts in many parts of the world.

The Big Thicket National Preserve is within the West Gulf Coastal Plain in southeastern Texas and represents a significant portion of the remaining sections of a large biological region historically termed the Big

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Thicket. The Big Thicket is a collection of diverse biological habitats formed as a result of the co-occurrence of several different ecosystems, including elements of eastern hardwood forests, central North American grasslands, subtropical coastal plains and southeastern swamps that converge on a single region (Watson 2006). Diggs et al. (2006) used the term "biological boundary" to describe the Big Thicket region as the western limit of the Southeastern Mixed Forest Province, encompassing both the diverse eastern deciduous forests and the Outer Coastal Plain Province, with the latter including some subtropical vegetation elements. The humid subtropical climate of the Big Thicket region is noted for the high amounts of rainfall when compared to other areas in Texas, which results in a number of wetland habitats such as upland wet pine savannahs, wetland baygalls, and tupelo- cypress swamps (Marks & Harcombe 1981; Diggs et al. 2006; MacRoberts & MacRoberts 2008).

The historical or original Big Thicket region, which may have once spread across nearly 1.5 million hectares, is highly impacted by human activities, including commercial tree plantations and oil and gas exploration in particular, which frequently have resulted in the clear-cutting of large areas of forest (Gunter 1993; Diggs et al. 2006; Watson 2006). These anthropogenic effects on the region are reflected in the disjunct nature of the property designated as the Big Thicket National Preserve. The Preserve now encompasses just over 40,000 ha of biological Big Thicket spread across seven counties in 15 disjunct units that are areas of preserved forest with corridors along waterways such as the Neches River, Menard Creek, Village Creek, Little Pine Island Bayou, and Big Sandy Creek that connect some of the Preserve divisions.

This checklist is the result of a multi-year survey of the Big Thicket National Preserve in cooperation with the All Taxa Biodiversity Inventory project, the Thicket of Diversity, organized and sponsored by the Big Thicket Association. As indicated below, data were generated through a combination of surveys for fruiting bodies of myxomycetes that had developed under natural conditions in the field and plant litter collections for laboratory cultivation of myxomycetes using the moist chamber culture technique.

MATERIALS AND METHODS

The list was prepared from specimens collected as a result of field-based surveys carried out in the Big Thicket National Preserve from 2007–2010. In all, five collecting trips of approximately five to ten days representing the spring, summer and fall seasons, were made to the Big Thicket National Preserve: June 2007, March 2008, October 2009, May 2010, and June 2010. Specimens were also isolated from samples of dead plant material collected in the field, returned to the laboratory, and used to prepare moist chamber cultures of the type used for myxomycetes.

Collecting sites.—Collecting localities were chosen based upon habitat type in order to survey all of the habitat types found within the Preserve. Each site was geo-referenced using a handheld GPS. Eleven of fifteen Preserve units were included in this survey (Table 1) with collecting localities indicated in Figure 1.

Field collections.—Myxomycetes found in nature were collected along with the piece of substratum upon which the fruiting bodies occurred. These collections were allowed to dry and then preserved according to a standard practice in which the specimen is glued (e.g. Elmer's white glue) to acid-free cardstock paper slips and placed in small cardboard slide pill boxes for permanent herbarium storage.

Laboratory cultivation.—Plant litter was collected for moist chamber from each collection locality. For the moist chamber culture technique, four general types of dead plant material were collected and placed in small paper bags. These were aerial litter (portions, generally leaves, of dead vegetation still standing and above the ground), bark from living trees (small pieces of the outer bark collected at approximately one meter from the base of the tree), coarse woody debris (twigs and woody material on the forest floor), and ground litter (decaying leaf litter on the forest floor). More specific litter types were collected from various collecting localities that represented unique types of plant material for that habitat. These more specific substrata are included as necessary in the annotated checklist. For each collection, three replicate moist chambers were prepared as follows. The plant material was placed in roughly a single layer in a sterile, disposable plastic Petri dish (9 cm diameter) with a disk of filter paper on the bottom of the dish. The dish was filled with non-sterile deionized water to

Table 1. Number of specimens and species collected in each Preserve unit as well as the major vegetation communities collected within each unit.

Big Thicket Preserve Unit	Number of Specimens	Number of Species	Number of Sites	Major Vegetation Community/ies* Collected
Beaumont	48	21	4	Floodplain hardwood forest
Beech Creek	47	27	3	Lower slope hardwood-pine forest
Big Sandy	64	29	7	Nyssa Floodplain Seasonally Flooded Forest; upper slope pine oak forest; floodplain hardwood-pine forest
Canyonlands	57	27	2	Upper slope pine-oak forest; mid-slope oak-pine forest; lower slope hardwood-pine forest; cypress-tupelo swamp forest
Hickory Creek Savannah	144	35	7	Wetland pine savannah; upland pine savannah
Jack Gore Baygall	49	24	3	Baygall; floodplain hardwood forest
Lance Rosier	245	49	14	Palmetto hardwood flatland forest; lower slope hardwood-pine forest
Little Pine Island Bayou	35	17	1	Palmetto hardwood flatland forest
Loblolly	24	17	1	Flatland hardwood forest
Menard Creek Corridor	103	39	3	Floodplain hardwood forest; lower slope hardwood-pine forest
Turkey Creek	42	18	3	Cypress-tupelo swamp forest; mid-slope pine-oak forest; upper slope pine-oak forest

*Vegetation communities based on information from Marks & Harcombe (1981), MacRoberts et al. (2002), Brown et al. (2005), Brown et al. (2006a, b), Watson (2006), Brown et al. (2008), Brown et al. (2008), Brown et al. (2009), and Brown et al. (2010).

cover the material and left standing to soak for 15–24 hours. The pH was measured using a portable pH meter from the standing water remaining after the material was soaked then excess water was poured out of the dish. Culture plates were checked weekly and maintained over a period of approximately 10 weeks in indirect light at room temperature. Deionized water was added as necessary to keep the litter moist but without free water in the dish. They were checked weekly using a dissecting microscope for fruiting body formation. Mature fruiting bodies were removed and preserved for herbarium storage as described above. All fruiting bodies of the same species that occurred in the same dish were considered to represent one record or collection. Interestingly, although the culture plates were maintained for 10 weeks, very few species were recorded after 4–5 weeks, and all of these had been recorded previously.

Specimen vouchers.—Vouchers are held in the University of Arkansas Myxomycete Collection (Fayetteville, AR), with duplicates deposited at the S.M. Tracy Herbarium (TAES), Texas A&M University (College Station, TX). Complete data is available online in the collection database at http://slimemold.uark.edu.

Checklist development.—All species represented by specimens collected during this project between June 2007 and June 2010 were included in this checklist. To determine which species were new to the Big Thicket and new to Texas, a thorough search of the literature and the available online databases were examined (e.g. Alexopolous 1965; McGraw 1968; Martin & Alexopolous 1969; Alexopolous & Henney 1971; Cooke 1971; Talley 1976; Talley & Williams 1978; Whitney 1980; Ndiritu et al. 2009; Eumycetozoan database at http://slimemold.uark.edu; Global Biodiversity Information Facility at http://gbif.org [GBIF]).

RESULTS AND DISCUSSION

The surveys carried out between 2007 and 2010 in the Big Thicket National Preserve yielded a total of 858 collections from 48 collecting sites (Figure 1). Fruiting bodies collected in the field accounted for 324 of the reported specimens. A total of 552 moist chamber cultures were prepared and examined from plant material collected at each site, and these resulted in 534 additional collections. Eighty-eight species were recorded for the Big Thicket. Of these, 53 were new records for the Preserve, and six are new records for the state. The number of specimens and species for each unit can be found in Table 1.

There were several noteworthy species collected that reflect the reported tropical and subtropical characteristics of the Big Thicket area (Diggs et al. 2006). *Craterium paraguayense* (Speg.) G. Lister is most commonly

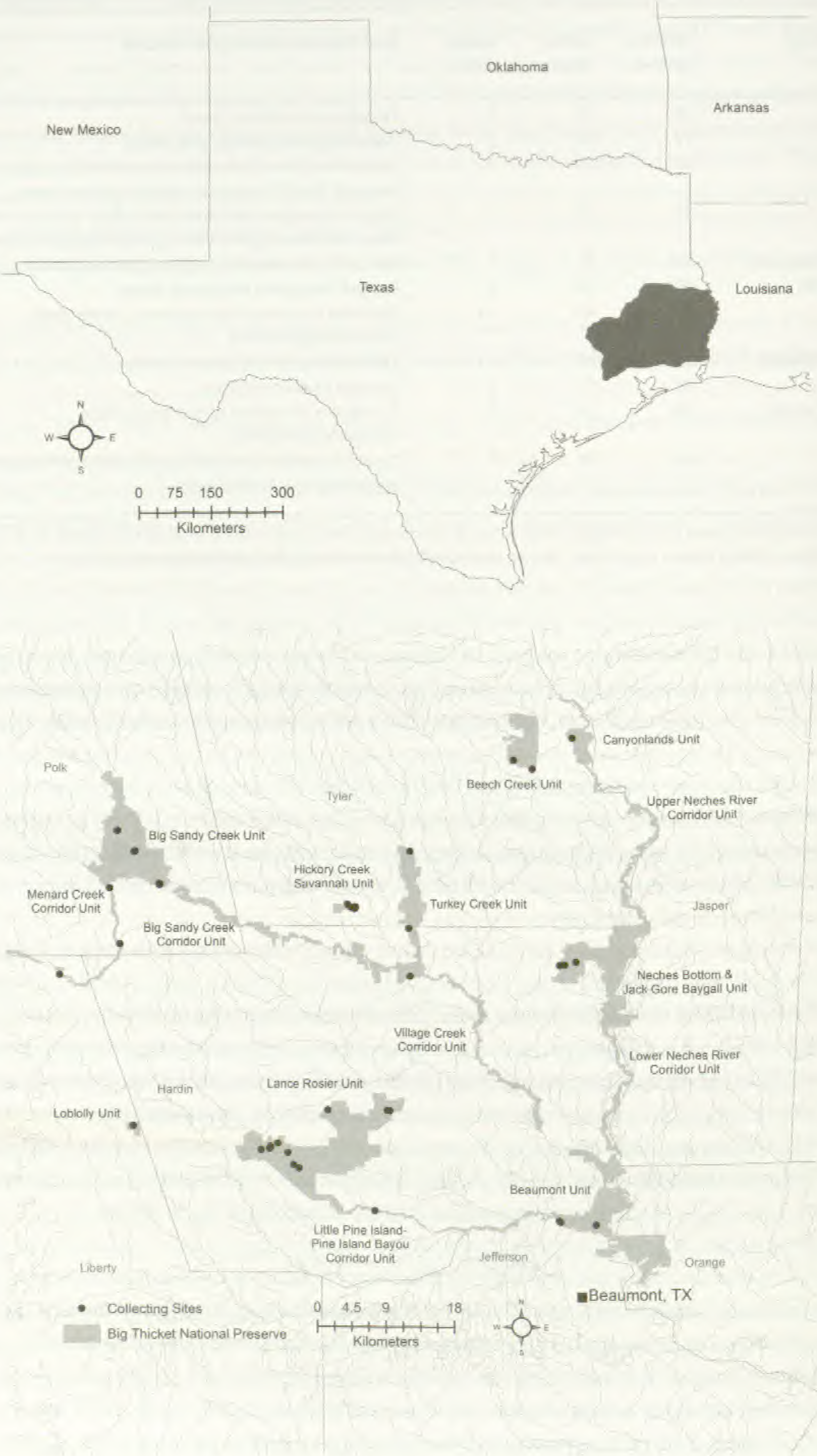
Oklahoma
Arkansas
New Mexico
Texas
Louisiana
N
W
E
S
0 75 150 300
Kilometers
Canyonlands Unit
Beech Creek Unit
Polk
Tyler
Upper Neches River Corridor Unit
Big Sandy Creek Unit
Hickory Creek Savannah Unit
Menard Creek Corridor Unit
Turkey Creek Unit
Jasper
Big Sandy Creek Corridor Unit
Neches Bottom & Jack Gore Baygall Unit
Village Creek Corridor Unit
Lower Neches River Corridor Unit
Hardin
Lance Rosier Unit
Loblolly Unit
Beaumont Unit
Little Pine Island-Pine Island Bayou Corridor Unit
Jefferson
Orange
Liberty
Beaumont, TX
● Collecting Sites
▨ Big Thicket National Preserve
0 4.5 9 18
Kilometers
N
W
E
S

Fig. 1. A map of collecting localities within the Big Thicket National Preserve in eastern Texas.

collected in subtropical and tropical forests (Global Biodiversity Information Facility [GBIF]). Although both are occasionally reported in temperate regions of the world, *Physarella oblonga* (Berk. & M.A. Curtis) Morgan and *Physarum bogoriense* Racib. have distributions centered largely in the tropics (Martin & Alexopolous 1969).

Arcyria margino-undulata Nann.-Bremek. & Y. Yamam. is an unexpected addition to the checklist for the Big Thicket. This is a rare species known from relatively few localities worldwide. Prior to this report, there were approximately 20 records of this species available in the worldwide database of eumycetozoans at the University of Arkansas and GBIF. These records indicate that this species has been found previously only in the state of West Virginia in the United States, France, Germany, the Netherlands, Switzerland, and Japan. The fact that the species was found in two separate localities in the Big Thicket National Preserve is noteworthy.

Seven species reported in the literature as having been found in the general study area were not recorded during the course of our surveys. McGraw (1968) recorded two species, *Reticularia jurana* Meyl. and *Stemonitopsis reticulata* (H.C.Gilbert) Nann.-Bremek.& Y.Yamam, which was reported as *Comatricha reticulata* H.C. Gilbert. Alexopoulos (1971) listed five species that were not found during our surveys. These were *Physarum pulcherrimum* Berk. & Ravenel., *Physarum pulcherripes* Peck, *Enerthenema berkeleyanum* Rostaf., *Lamproderma scintillans* (Berk. & Broome) Morgan, and *Hemitrichia clavata* (Pers.) Rostaf.

It is evident from our collecting effort that myxomycetes are a common component of the ecosystems within the Big Thicket National Preserve. Evidence of myxomycetes appeared in nearly 75% of all moist chamber cultures prepared, with approximately 40% of those having evidence of multiple species. Despite the indications of an abundance of myxomycetes in the Big Thicket, the implications of this with regards to their function, particularly in the soil environment, are still quite limited. The data presented in this checklist establish a framework for the further development of more focused ecological studies within the Big Thicket in order to more fully connect the observations regarding myxomycetes to the unique ecosystems found in this area.

ANNOTATED CHECKLIST

The annotated checklist that follows is organized alphabetically first by genus and then by specific epithet in the six orders traditionally recognized for myxomycetes. In most cases, nomenclature follows Lado (2005–2012). It should be noted that the nomenclatural treatment of the myxomycetes proposed by Lado differs in a number of respects from that used traditionally by North American myxomycologists. For example, Lado recognized several genera (e.g., *Collaria* and *Stemonitopsis*) not included in Martin and Alexopoulos (1969), long considered as the standard source for myxomycete nomenclature. However, most recent publications have used Lado 2001, which is the approach followed in this paper. The total number of collections from each park unit is given in parentheses. The months in which specimens were collected in the field (fc) are listed followed by the months that the litter was collected from which the species was recorded in moist chamber (mc). Species that represent new records for the Big Thicket are indicated by an asterisk (*). Species that may represent new records for Texas are indicated by the state abbreviation (TX).

The following abbreviations are used to represent the park units in which each species was collected:

B	Beaumont
BC	Beech Creek
BS	Big Sandy
CL	Canyonlands
HCS	Hickory Creek Savannah
JGB	Jack Gore Baygall
L	Loblolly
LPIB	Little Pine Island Bayou
LR	Lance Rosier
MCC	Menard Creek Corridor
TC	Turkey Creek

CERATIOMYXALES

Ceratiomyxa fruticulosa (O.F. Müll.) T. Macbr.
B (1), BC (3), BS (3), HCS (2), JGB (2), L (1), LR (6), MCC (2)
fc: May 2010, Jun 2007, 2010, Oct 2009
Collected in the field on decaying decorticated coarse woody debris from pine (*Pinus* spp.) and unidentified trees. Reported previously by McGraw (1968).

ECHINOSTELIALES

***Clastoderma debaryanum** A. Blytt
B (2), BS (1), CL (1), HCS (7), LR (1), TC (2)
fc: Oct 2009; mc: Mar 2008, Jun 2007, Oct 2009
One field collection associated with coarse woody debris. Eleven collections from moist chamber cultures prepared with samples of twigs, pine bark from living trees, bark from unidentified trees, pine needle ground litter, and aerial litter represented by pine twigs.

*(TX) **Echinostelium apitectum** K.D. Whitney
CL (1), HCS (2)
mc: Mar 2008, Oct 2009
All collections from moist chamber cultures prepared with pine bark from living trees.

***Echinostelium minutum** de Bary
B (2), BC (5), CL (1), HCS (8), JGB (1), LR (14), MCC (2), TC (2)
mc: Mar 2008, Jun 2007, 2010, Oct 2009
All collections from moist chamber cultures prepared with pine bark from living trees, aerial litter, angiosperm bark, ground litter, aerial litter composed of the inflorescences from pitcher plants (*Sarracenia alata* Alph. Wood), twigs, aerial litter from dwarf palmetto (*Sabal minor* [Jacq.] Pers.), and coarse woody debris.

LICEALES

***Cribraria aurantiaca** Schrad.
LR (1), JGB (1)
fc: Jun 2007, 2010
Collected in the field on decaying decorticated coarse woody debris.

Cribraria cancellata (Batsch) Nann.-Bremek.
BS (1), CL (1), HCS (4), JGB (1), L (1), LR (8)
fc: May 2010, Jun 2007, 2010, Oct 2009; mc: Jun 2007
Fifteen field collections found associated with decaying decorticated coarse woody debris. One collection from a moist chamber culture prepared with a sample of ground litter composed of woody debris. Reported previously (as *Dictydium cancellatum* [Batsch] T. Macbr.) by McGraw (1968).

*(TX) **Cribraria confusa** Nann.-Bremek. & Y.Yamam.
BC (1), BS (4), HCS (10), JGB (2), LPIB (1), LR (20), MCC (3)
mc: Mar 2008, May 2010, Jun 2007, 2010, Oct 2009
All collections from moist chamber cultures prepared with samples of coarse woody debris, pine bark from living trees, burned pine bark from living trees, and bark from unidentified trees.

Cribraria intricata Schrad.
BC (2), LR (4), L (2), LPIB (1)
fc: Jun 2007, 2010, Oct 2009
Nine field collections associated with decaying decorticated coarse woody debris. Reported previously by McGraw (1968).

Cribraria languescens Rex
HCS (4), JGB (2), L (1), LR (3)
fc: Jun 2007, Oct 2009; mc: Jun 2007
Eight field collections associated with decaying coarse woody debris. One collection from a moist chamber culture prepared with a sample of pine coarse woody debris. Reported previously by McGraw (1968).

Cribraria microcarpa (Schrad.) Pers.
HCS (20), JGB (2), L (3), LR (9), MCC (4), TC (7)
fc: Jun 2007, 2010, Oct 2009; mc: Mar 2008, Jun 2007, 2010, Oct 2009
Five field collections associated with coarse woody debris. Thirty-eight collections from moist chamber cultures prepared with samples of coarse woody debris, twigs, pine bark from living trees, bark from unidentified trees, aerial litter, aerial litter composed of the inflorescences from pitcher plants, aerial litter from bracken fern (*Pteridium aquilinum* [L.] Kuhn), ground litter, pine needle ground litter, and sphagnum (*Sphagnum* spp.) Reported previously by McGraw (1968).

***Cribraria minutissima** Schwein.
JGB (1)
fc: Jun 2007
Collected in the field from decaying coarse woody debris.

***Cribraria piriformis** Schrad.
LR (2)
fc: Oct 2009
Collected in the field from decaying pine coarse woody debris.

*(TX) **Cribraria tenella** Schrad.
fc: JGB (2)
Jun 2007
Collected in the field from decaying coarse woody debris.

***Cribraria violacea** Rex
BC (2), BS (1), CL (2), LR (1), MCC (4), TC (1)
mc: Mar 2008, Jun 2007, 2010, Oct 2009
All collections from moist chamber cultures prepared with samples of bark from sweet gum (*Liquidambar styraciflua* L.), bark from unidentified trees, aerial litter, and coarse woody debris.

***Cribraria vulgaris** Schrad.
L (1)
fc: Jun 2007
Collected in the field from decaying coarse woody debris.

***Licea biforis** Morgan
MCC (1)
mc: Oct 2009
Collected from a moist chamber culture prepared with a sample of aerial litter.

***Licea kleistobolus** G.W. Martin
JGB (1)
fc: Jun 2007
Collected in the field on decaying coarse woody debris.

Licea operculata (Wingate) G.W. Martin
HCS (1)
mc: Oct 2009
Collected from a moist chamber culture prepared with a sample of pine bark from living trees. Reported previously by McGraw (1968).

Lycogala epidendrum (L.) Fr.
BC (3), HCS (3), JGB (3), L (2), LR (7), LPIB (1), MCC (2), TC (1)
fc: Jun 2007, 2010, Oct 2009; mc: Mar 2008, Jun 2007, 2010
Eighteen field collections associated with decaying coarse woody debris. Three collections from moist chamber cultures prepared with samples of pine bark from living trees and twigs. Reported previously by McGraw (1968). This species rarely appears in moist chamber culture, but small but perfectly formed aethalia were recorded in the present study. The species also appeared on samples of white oak (*Quercus alba* L.) bark the second author collected in northwest Arkansas. The occurrence in moist chamber cultures of species known almost exclusively from ground sites is an interesting aspect of the potential ecological distribution of myxomycetes. In addition to *Lycogala epidendrum*, two other "ground site" species that are sometimes collected from moist chambers are *Metatrichia vesparia* and *Trichia favoginea*, both of which were recorded from both types of situations in the present study.

Lycogala exiguum Morgan
MCC (2)
fc: May 2010, Oct 2009
Collected in the field from decaying pine coarse woody debris and decaying coarse woody debris from unidentified trees. Reported previously by McGraw (1968).

Tubifera ferruginosa (Batsch) J.F. Gmel.
LR (1)
fc: Jun 2010
Collected in the field from decaying coarse woody debris. Reported previously by McGraw (1968).

PHYSARALES

***Badhamia melanospora** Speg.
HCS (1)
mc: Mar 2008
Collected from a moist chamber culture prepared with a sample of ground litter.

***Craterium aureum** (Schumach.) Rostaf.
MCC (1)
mc: May 2010
Collected from a moist chamber culture prepared with a sample of aerial litter.

***Craterium paraguayense** (Speg.) G. Lister
CL (1)
fc: Oct 2009
Collected in the field on ground litter from beech (*Fagus grandifolia* Ehrh.) and oak (*Quercus* spp.).

***Diachea leucopodia** (Bull.) Rostaf.
B (1), BC (1), CL (1), HCS (1), LR (4), MCC (3)
fc: Jun 2010; mc: Jun 2007, 2010, Oct 2009
One field collection associated with ground litter from cypress (*Taxodium distichum* [L.] Rich.). Ten collections from moist chamber cultures prepared with samples of coarse woody debris, aerial litter from oak, and aerial litter from ironwood (*Ostrya virginiana* [Mill.] K. Koch).

***Diderma chondrioderma** (de Bary & Rostaf.) G. Lister
CL (1)
mc: Mar 2008
Collected from a moist chamber culture prepared with a sample of bark.

***Diderma effusum** (Schwein.) Morgan
B (5), BS (3), CL (1), LR (5), L (1), LPIB (3), MCC (10), TC (3)
fc: Jun 2010; mc: Mar 2008, May 2010, Jun 2007, 2010, Oct 2009
One field collection associated with decaying coarse woody debris. Twenty-eight collections from moist chamber cultures prepared with samples of aerial litter, aerial litter from oak, aerial litter from ironwood, bark and leaf litter from tupelo (*Nyssa aquatica* L.), and bark from unidentified trees.

***Diderma hemisphaericum** (Bull.) Hornem.
BS (2), CL (1), HCS (1), LR (1), MCC (1)
mc: Mar 2008, May 2010, Jun 2007
All collections from moist chamber cultures prepared with samples of pine bark from living trees, bark from unidentified trees, ground litter, aerial litter, and aerial litter represented by needles from red cedar (*Juniperus virginiana* L.).

***Didymium iridis** (Ditmar) Fr.
HCS (1), TC (1)
mc: Mar 2008, Jun 2007
Collected from moist chamber cultures prepared with samples of ground litter.

***Didymium cf. minus** (Lister) Morgan
B (1), BS (1)
mc: Jun 2007, Oct 2009
Collected from moist chamber cultures prepared with samples of aerial litter and bark. These collections are limited to just a few sporocarps, so this identification is somewhat problematic. However, they clearly represent a species of *Didymium* that is different from other member of the genus recorded in the present study.

***Didymium nigripes** (Link) Fr.
CL (2), HCS (1), LR (1), TC (1)
fc: Jun 2007; mc: Mar 2008, Jun 2007, Oct 2009
One field collection associated with decaying coarse woody debris. Four collections from moist chamber cultures prepared with samples of ground litter.

***Didymium pertusum** Berk.
MCC (1)
mc: Oct 2009
Collected from a moist chamber culture prepared with a sample of aerial litter from magnolia (*Magnolia grandiflora* L.). Martin and Alexopoulos (1969) did not recognize *Didymium pertusum* as a distinct taxonomic entity, but the species is included in a number of the more recent monographs (e.g., Ing 1999). As it is morphologically similar to other species of *Didymium*, the validity of *D. pertusum* presents an interesting question in myxomycete taxonomy. An ongoing investigation by the first author is utilizing molecular tools together with laboratory cultivation on agar to more fully understand the taxon and its relationship to other species within the genus (Winsett and Parks, unpublished data).

***Didymium squamulosum** (Alb. & Schwein.) Fr.
MCC (3)
mc: May 2010, Oct 2009
All collections from moist chamber cultures prepared with samples of bark, aerial litter, and aerial litter from magnolia.

Fuligo septica (L.) F.H. Wigg.
HCS (1), LPIB (1), MCC (1)
fc: May 2010, Jun 2007, Oct 2009
Collected in the field from decaying coarse woody debris. Reported previously by McGraw (1968).

Physarella oblonga (Berk. & M.A. Curtis) Morgan
B (1)
fc: Oct 2009
Collected in the field from decaying coarse woody debris. Reported previously by McGraw (1968).

***Physarum album** (Bull.) Chevall.
BS (5), CL (5), LR (11), TC (1)
fc: Oct 2009; mc: Mar 2008, Jun 2007
One field collection associated with decaying coarse woody debris. Eighteen collections from moist chamber cultures prepared with samples of pine bark from living trees and bark from unidentified trees.

***Physarum bivalve** Pers.
HCS (1)
mc: Jun 2007
Collected from a moist chamber culture prepared with a sample of pine bark from living trees.

***Physarum bogoriense** Racib.
LPIB (2)
mc: Oct 2009
Collected in moist chamber cultures prepared with samples of ground litter and coarse woody debris.

***Physarum cinereum** (Batsch) Pers.
MCC (1)
mc: Oct 2009
Collected from a moist chamber culture prepared with a sample of aerial litter from magnolia.

***Physarum crateriforme** Petch
BS (1), CL (1), JGB (1), MCC (1)
fc: Jun 2007; mc: Mar 2008, May 2010, Jun 2007
One field collection associated with decaying coarse woody debris. Three collections from moist chamber cultures prepared with samples of bark and aerial litter.

***Physarum galbeum** Wingate
BC (1), HCS (6), LR (1), MCC (1)
mc: Jun 2007, 2010, Oct 2009
All collections from moist chamber cultures prepared with samples of coarse woody debris, aerial litter, aerial litter composed of the inflorescences from pitcher plants, aerial litter from oak, and aerial litter represented by twigs.

Physarum globuliferum (Bull.) Pers.
B (1), BS (2), L (1), LPIB (2)
fc: Jun 2007, 2010, Oct 2009
Collected in the field from decaying coarse woody debris. Reported previously by McGraw (1968).

***Physarum leucophaeum** Fr.
BS (1)
mc: Jun 2007
Collected in a moist chamber culture prepared with a sample of bark.

Physarum melleum (Berk. & Broome) Massee
LR (1), MCC (2)
mc: May 2010, Jun 2007
Collected from moist chamber cultures prepared with samples of aerial litter from holly (*Ilex opaca* Aton.), bark from unidentified trees, and coarse woody debris. Reported previously by McGraw (1968).

***Physarum nucleatum** Rex
LR (1), L (1)
fc: Jun 2007
Collected in the field on decaying coarse woody debris.

***Physarum oblatum** T. Macbr.
CL (1)
mc: Mar 2008
Collected from a moist chamber culture prepared with a sample of ground litter.

***Physarum pusillum** (Berk. & M.A. Curtis) G. Lister
LPIB (2), LR (5), MCC (2)
mc: May 2010, Jun 2007, Oct 2009
All collections from moist chamber cultures prepared with samples of bark, twigs, bark and leaf ground litter from tupelo, aerial litter, and aerial litter represented by holly twigs.

Physarum roseum Berk. & Broome
BC (1), LR (1)
mc: Jun 2007, 2010
All collections from moist chamber cultures prepared with samples of ground litter. Reported previously by McGraw (1968).

Physarum stellatum (Massee) G.W. Martin
LR (1)
fc: Oct 2009
Collected in the field from decaying coarse woody debris. Reported previously by McGraw (1968).

Physarum tenerum Rex
B (1), BS (2), L (1), LPIB (1)
fc: Jun 2007, 2010, Oct 2009
Collected in the field from decaying coarse woody debris. Reported previously by McGraw (1968).

Physarum viride (Bull.) Pers.
B (2), BC (4), BS (4), HCS (2), LR (13), L (1), MCC (3), TC (2)
fc: Jun 2007, 2010, Oct 2009; mc: May 2010, Jun 2007, 2010, Oct 2009
Eleven field collections associated with decaying coarse woody debris from beech and decaying coarse woody debris from unidentified trees. Sixteen collections from moist chamber cultures prepared with samples of pine bark from living trees, bark from unidentified trees, and ground litter of burned pine bark from living trees. Reported previously by McGraw (1968).

***Willkommlangia reticulata** (Alb. & Schwein.) Kuntze
B (1), MCC (2), TC (1)
mc: Mar 2008, May 2010, Oct 2009
All collections from moist chamber cultures prepared with samples of bark, twigs, and coarse woody debris.

STEMONITALES

Collaria arcyrionema (Rost.) Nann.-Bremek. ex Lado
B (5), BC (3), BS (1), CL (8), HCS (4), JGB (4), LR (11), LPIB (1), L (1), MCC (3), TC (2)
fc: May 2010, Jun 2007, 2010, Oct 2009; mc: Jun 2007, Mar 2008, Oct 2009
Fourteen field collections associated with decaying pine coarse woody debris and decaying coarse woody debris. Twenty-eight collections from moist chamber cultures prepared with samples of bark from sweet gum, pine bark from living trees, and bark from unidentified trees, coarse woody debris from pine, coarse woody debris, ground litter, leaf and bark ground litter from tupelo, twigs, aerial litter, and aerial litter represented by holly twigs. Reported previously (as *Lamproderma arcyrionema* Rost.) by McGraw (1968).

Collaria lurida (Lister) Nann.-Bremek.
HCS (6)
mc: Jun 2007
All collections from moist chamber cultures prepared with samples of ground litter, ground litter from bracken fern, and aerial litter composed of the inflorescences from pitcher plants. Reported previously (as *Comatricha lurida* Lister) by Alexopoulos and Henney (1971).

Comatricha elegans (Racib.) G. Lister
BS (1), HCS (7), JGB (2), LR (5), MCC (1)
mc: May 2010, Jun 2007, Oct 2009
All collections from moist chamber cultures prepared with samples of pine bark from living trees, burned pine bark from living trees, bark from unidentified trees, coarse woody debris, and pine needle ground litter. Reported previously by McGraw (1968).

***Comatricha laxa** Rostaf.
CL (1), MCC (1)
mc: Mar 2008, May 2010
Collected from moist chamber cultures prepared with samples of ground litter and aerial litter.

***Comatricha nigra** (Pers. ex. J.F. Gmel.) J. Schröt.
BS (1), HCS (1), LR (3), MCC (1)
mc: Jun 2007, Oct 2009
All collections from moist chamber cultures prepared with samples of pine bark from living trees, bark from unidentified trees, and pine needle ground litter.

***Comatricha pulchella** (C. Bab.) Rostaf.
B (3), BC (2), HCS (4), JGB (2), LPIB (4), LR (4), MCC (2), TC (3)
fc: Jun 2007; mc: Jun 2010, Oct 2009
Two field collections associated with decaying coarse woody debris. Twenty-two collections from moist chamber cultures prepared with samples of coarse woody debris, twigs, bark, pine needle ground litter, ground litter, aerial litter, aerial litter from oak, aerial litter represented by pine needles, and aerial litter composed of the inflorescences from pitcher plants.

***Comatricha tenerrima** (M.A. Curtis) G. Lister
B (1), LR (1)
mc: Jun 2007, Oct 2009
Collected from moist chamber cultures prepared with samples of coarse woody debris and aerial litter represented by twigs.

Enerthenema papillatum (Pers.) Rostaf.
BC (1), LR (4)
fc: Jun 2010; mc: Jun 2007
One field collection associated with decaying coarse woody debris. Four collections from moist chamber cultures prepared with samples of pine bark from living trees and bark from unidentified trees. Reported previously by McGraw (1968).

***Macbrideola cornea** (G. Lister & Cran) Alexop.
BC (1)
mc: Jun 2010
Collected from a moist chamber culture prepared with a sample of bark.

***Macbrideola decapillata** H.C. Gilbert
LR (1)
mc: Jun 2007
Collected from a moist chamber culture prepared with a sample of twigs.

Stemonitis axifera (Bull.) T. Macbr
BC (2), BS (2), CL (2), JGB (1), LPIB (2), LR (3), MCC (2)
fc: May 2010, Jun 2007, 2010, Oct 2009; mc: Oct 2009
Thirteen field collections associated with decaying coarse woody debris. One collection from a moist chamber culture prepared with a sample of coarse woody debris. Reported previously by McGraw (1968).

Stemonitis flavogenita E. Jahn
BC (2), JGB (1), LR (1)
fc: Jun 2007, 2010
Collected in the field on decaying coarse woody debris. Reported previously by McGraw (1968).

Stemonitis fusca Roth
BS (3), CL (1), HCS (2), JGB (2), LR (8), TC (1)
fc: May 2010, Jun 2007, 2010; mc: Mar 2008
Fourteen field collections associated with decaying coarse woody debris. Three collections from moist chamber cultures prepared with samples of twigs and ground litter. Reported previously by McGraw (1968).

***Stemonitis fusca** var. **nigrescens** (Rex) Torrend.
B (3), BC (1), CL (1), LR (3), MCC (2), TC (1)
fc: Jun 2010; mc: Jun 2007, Oct 2009
One field collection associated with decaying coarse woody debris. Ten collections from moist chamber cultures prepared with samples of coarse woody debris, ground litter, aerial litter, aerial litter from magnolia, and aerial litter from oak.

Stemonitis herbatica Peck
HCS (2), JGB (1), MCC (1)
fc: May 2010, Jun 2007, 2010; mc: Jun 2007
Three field collections associated with decaying coarse woody debris. One collection from a moist chamber culture prepared with a sample of bark. Reported previously by McGraw (1968).

Stemonitis smithii T. Macbr.
HCS (1), LR (2), LPIB (3)
fc: Jun 2010, Oct 2009; mc: Jun 2007
Five field collections associated with decaying coarse woody debris and decaying woody debris from pine. One collection from a moist chamber culture prepared with a sample of bark. Reported previously by McGraw (1968).

***Stemonitis splendens** Rostaf.
LPIB (1), LR (2)
fc: Jun 2007, 2010; Oct 2009
Collected in the field on decaying coarse woody debris.

Stemonitis virginiensis Rex
BC (1)
mc: Jun 2007
Collected in a moist chamber culture prepared with a sample of aerial litter. Reported previously by McGraw (1968).

***Stemonitopsis hyperopta** (Meyl.) Nann.-Bremek.
LR (3)
fc: May 2010, Jun 2010
Collected in the field on decaying wood and decaying cypress coarse woody debris.

Stemonitopsis typhina (F.H. Wigg.) Nann.-Bremek.
B (1), BS (1), CL (1), JGB (2), L (1), LR (3)
fc: May 2010, Jun 2007, 2010, Oct 2009
Collected in the field on decaying coarse woody debris. Previously reported (as *Comatricha typhoides* [Bull.] Rostaf.) by McGraw (1968).

TRICHIALES

Arcyria cinerea (Bull.) Pers.
B (9), BC (9), BS (12), CL (6), HCS (26), JGB (13), LR (41), LPIB (5), L (5), MCC (17), TC (12)
fc: May 2010, Jun 2007, 2010, Oct 2009; mc: Mar 2008, May 2010, Jun 2007, 2010, Oct 2009
Forty-three field collections associated with pine coarse woody debris, coarse woody debris from beech, and decaying coarse woody debris. Ninety-five collections from moist chamber cultures prepared with samples of twigs, coarse woody debris, pine bark from living trees, bark from unidentified trees, ground litter, pine needle ground litter, aerial litter, aerial litter composed of the inflorescences from pitcher plants, and sphagnum. Reported previously by McGraw (1968).

Arcyria denudata (L.) Wettst.
BC (3), BS (2), CL (4), HCS (4), JGB (2), LR (15), LPIB (4), L (2), MCC (9), TC (1)
fc: May 2010, Jun 2007, 2010, Oct 2009; mc: Jun 2007, 2010, Oct 2009
Twenty-eight field collections associated with decaying coarse woody debris and decaying pine woody debris. Fourteen collections from moist chamber cultures prepared with samples of coarse woody debris, bark from beech, pine twigs, aerial litter represented by twigs, aerial litter, and ground litter. Reported previously by McGraw (1968).

Arcyria incarnata (Pers. ex J.F. Gmel.) Pers,
LR (1)
fc: Jun 2010
Collected in the field from decaying coarse woody debris. Reported previously by McGraw (1968).

*(TX) **Arcyria margino-undulata** Nann.-Bremek. & Y. Yamam.
BC (1), MCC (1)
mc: Jun 2010, Oct 2009
Collected from moist chamber cultures prepared with samples of ground litter and coarse woody debris.

***Arcyria pomiformis** (Leers) Rostaf.
BC (1), JGB (1)
fc: Jun 2007; mc: Jun 2007
One field collection associated with decaying coarse woody debris. One collection from a moist chamber culture prepared with a sample of bark.

***Calonema aureum** Morgan
HCS (1)
fc: Jun 2007
Collected in the field from decaying coarse woody debris.

Hemitrichia calyculata (Speg.) M.L. Farr
B (3), BC (1), BS (3), CL (3), HCS (1), JGB (2), L (1), LPIB (3), LR (20), MCC (9)
fc: May 2010, Jun 2007, 2010, Oct 2009; mc: Jun 2007
Forty-three field collections associated with decaying coarse woody debris. One collection from a moist chamber culture prepared with a sample of bark. Previously reported (as *H. stipitata* [Massee] T. Macbr.) by McGraw (1968).

*(TX) **Hemitrichia pardina** (Minakata) Ing
BC (1), CL (1)
mc: Jun 2010, Oct 2009
All collections from moist chamber cultures prepared with samples of bark and ground litter from beech and oak.

Metatrichia vesparia (Batsch) Nann.-Bramek. ex G.W. Martin & Alexop.
B (2), CL (6), HCS (3), LR (4), MCC (1)
fc: May 2010, Jun 2007, 2010, Oct 2009; mc: Jun 2007, Oct 2009
Nine field collections associated with decaying coarse woody debris. Six collections from moist chamber cultures prepared with samples of beech bark, coarse woody debris, ground litter from holly, and pine needle ground litter. Previously reported (as *Hemitrichia vesparia* [Batsch] T. Macbr.) by McGraw (1968). In all but the most recent publications on the myxomycetes, species is given as *M. vesparium*. However, Lado (2005-2012) considered as the correct spelling of the specific epithet to be *vesparia* instead of *vesparium*.

***Perichaena chrysosperma** (Curr.) Lister
B (4), BC (2), BS (9), CL (3), HCS (3), LR (1), MCC (7), TC (2)
mc: Jun 2007, Oct 2009
All collections from moist chamber cultures prepared with samples of bark from sweet gum, bark from beech, bark from unidentified trees, samples of twigs, coarse woody debris, ground litter, and aerial litter.

***Perichaena corticalis** (Batsch) Rostaf.
MCC (1)
mc: Oct 2009
Collected from a moist chamber culture prepared with a sample of bark. There are relatively few records of this species from bark, although in some situations (e.g., Novozhilov et al. 2006) it can be relatively abundant on this substratum.

***Perichaena depressa** Lib.
B (1), BS (2), HCS (1), LR (3)
mc: Jun 2007
All collections from moist chamber cultures prepared with samples of twigs, bark, ground litter, aerial litter, and aerial litter represented by holly twigs.

Perichaena microspora Penz. & Lister
BS (1)
mc: Jun 2007
Collected from a moist chamber culture prepared with samples of ground litter from magnolia. Reported previously by McGraw (1968).

***Perichaena vermicularis** (Schwein.) Rostaf.
BC (1), MCC (1)
mc: Jun 2007, Oct 2009
Collected from moist chamber cultures prepared with samples of ground litter and aerial litter.

Trichia favoginea (Batsch) Pers.
BS (1), HCS (4), LR (1), MCC (1)
fc: Jun 2007, 2010; mc: Jun 2007, Oct 2009
Five field collections associated with decaying coarse woody debris. Two collections from moist chamber cultures prepared with samples of bark from fallen tree and ground litter. Reported previously by McGraw (1968).

*(TX) **Trichia munda** (Lister) Meyl.
BC (1), BS (1)
mc: Jun 2007
Collected from moist chamber cultures prepared with samples of ground litter and bark.

ACKNOWLEDGMENTS

This work was done in cooperation with and funding from the Big Thicket Association. Additional funding was provided by the National Science Foundation (grant DEB-0316284 to the University of Arkansas), the University of Arkansas Department of Biological Sciences, and the Eastfield College Science Talent Expansion Program (NSF-STEP). We wish to extend our gratitude to the personnel at the Big Thicket National Preserve and the staff at the Big Thicket Field Research Station for invaluable scientific and logistical support. A number of people contributed to the field survey effort, including Paul Roling, Dale Kruse, David Lewis, Mona Halvorson, and Jane Packard. Two student researchers, Sara Hays and Rafael Gutierrez from the NSF-STEP project at Eastfield College, contributed to the field and laboratory effort early in this project. We are grateful to Lamar University for the loan of physical specimen data and wish to recognize the S.M. Tracy Herbarium (TAES) at Texas A&M University for depositing all of the McGraw specimens and our duplicates into their permanent collection. The input provided by two anonymous reviewers on an earlier version of this manuscript is greatly appreciated.

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CYPERUS ALBOSTRIATUS (CYPERACEAE) NEW TO NORTH AMERICA AND *FIMBRISTYLIS CYMOSA* (CYPERACEAE) NEW TO TEXAS

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ABSTRACT

Cyperus albostriatus is reported as a naturalized component of the North American flora based upon recent collections from Harris County, Texas. *Fimbristylis cymosa* was recently collected from Padre Island in Cameron County and is reported new to the Texas flora.

RESUMEN

Se cita *Cyperus albostriatus* como un componente naturalizado de la flora de Norte América basados en colecciones recientes en el condado de Harris, Texas. *Fimbristylis cymosa* se colectó recientemente en Padre Island en el condado de Cameron y se cita como nueva para la flora de Texas.

Cyperus albostriatus

During routine field work in 2004, the first author vouchered an unknown *Cyperus*, determined it as *C. diffusus* Vahl, and sent it to Richard Carter for confirmation. The plant was subsequently determined to be the similar species, *Cyperus albostriatus* Schrad. Native to southern Africa (Kükenthal 1935–1936), *C. albostriatus* has not previously been reported from North America (cf., Tucker et al. 2002).

Voucher specimen: **USA. Texas. Harris Co.:** Houston, in the floodplain of White Oak Bayou, about 0.6 mi SW of the intersection of Hwy. 610 and Ella Blvd., a local green-space known as Little Thicket Park with about 7 acres of undisturbed remnant riparian forest, abundant rhizomatous herb apparently escaping from cultivation and well established in shaded mesic slopes with *Carpinus, Prunus, Acer, Populus, Fraxinus,* and *Ulmus,* N29°48'24.0" W95°25'53.8" (NAD83), 26 Jul 2004, *D.J. Rosen 3028* (VSC). Fig. 1.

Although not listed as such by Bailey (1949), *Cyperus albostriatus* is frequently cited as an ornamental (e.g., Bailey 1935; Bailey & Bailey 1976; Everett 1980–1982; Greenlee & Fell 1992; Brickell & Zuk 1997; Turner & Wasson 1998; Darke 1999). Kükenthal (1935–1936) indicated *C. albostriatus* is widespread in southern Africa and described its habitat as swampy places, shores, and forests. According to Gordon-Gray (1995), *C. albostriatus* is "frequent in Natal in shaded, often rocky, not necessarily damp situations on margins of forest, in woodland and in plantations of exotics (pines, rarely eucalypts)," and in New South Wales, Australia, it is frequently cultivated as an ornamental and has become naturalized (Wilson 1993). It has been cited as a weed in Australia and New Zealand (Healy and Edgar 1980; Simpson and Inglis 2001; Bryson and Carter 2008).

Kükenthal (1935–1936) treated *Cyperus albostriatus* in section *Diffusi* Kunth. Its slender elongate rhizomes, major veins of dried primary inflorescence bracts and leaves adaxially white banded, and floral scales with conspicuously ciliate margins readily distinguish it from other Texas *Cyperus*.

Fimbristylis cymosa R. Br. was recently collected in sandy, disturbed soils in southern coastal Texas, not being previously reported therein (Correll & Johnston 1970; Jones et al. 1997). *Fimbristylis cymosa* is a wide-

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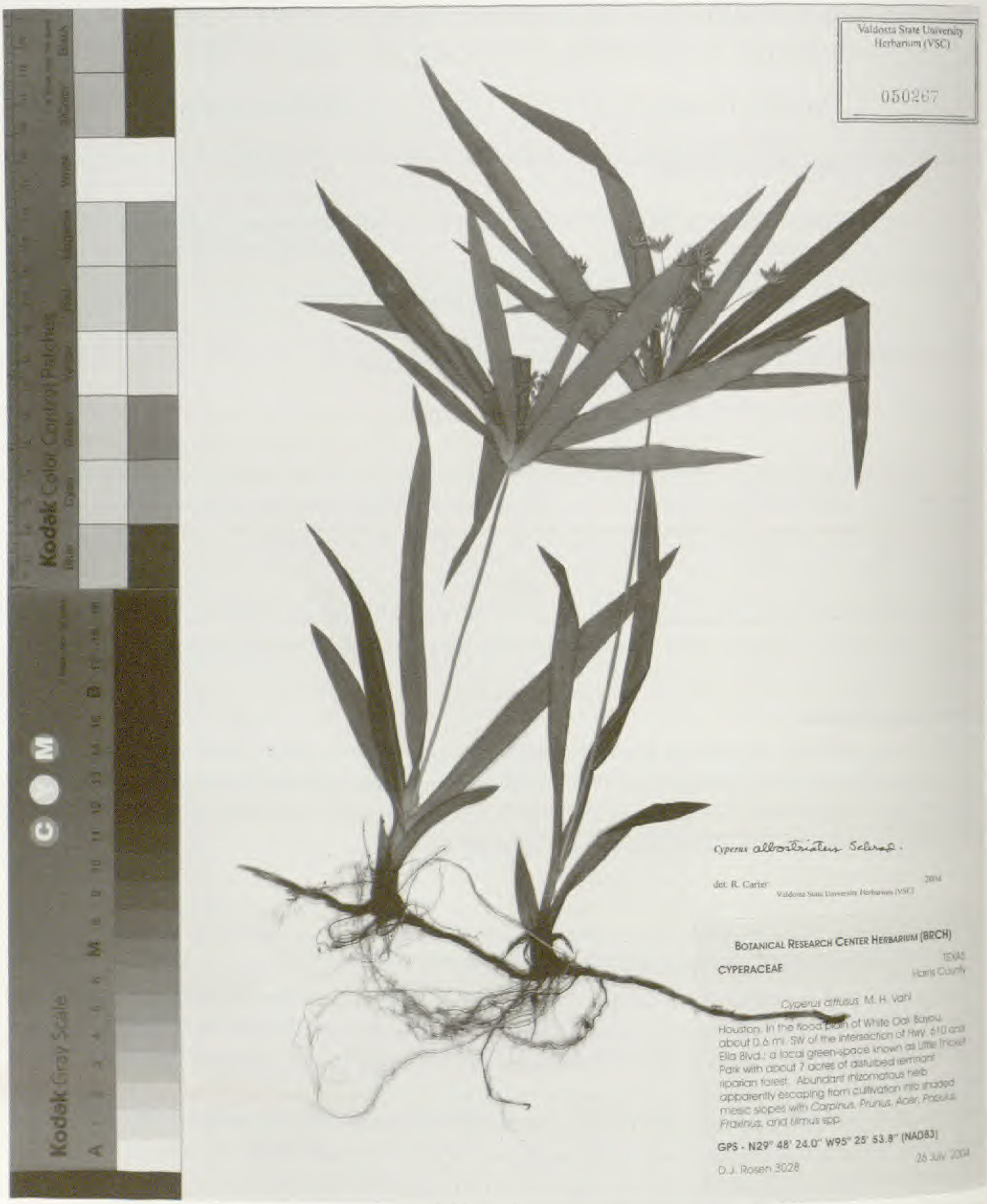
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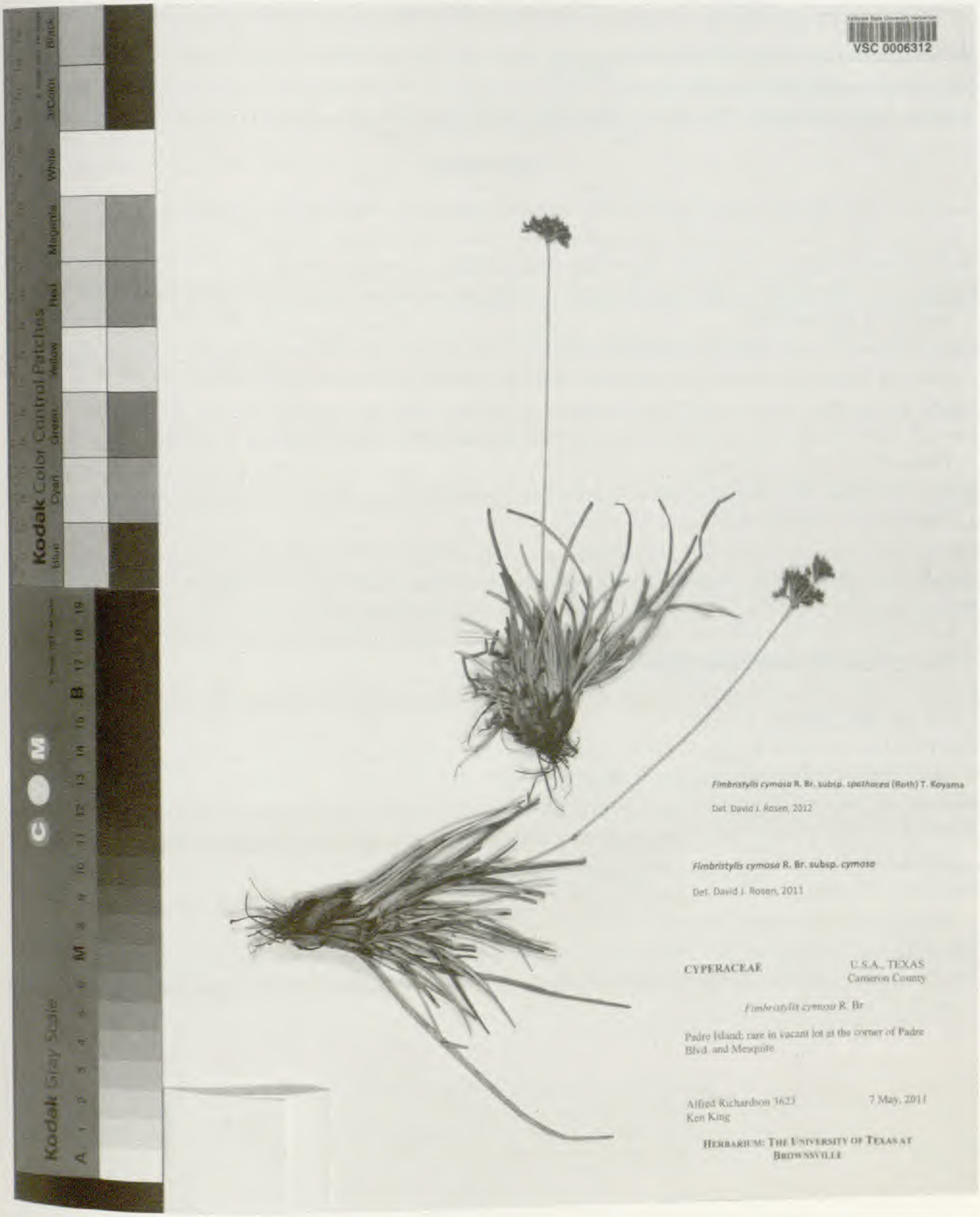
Cyperus albostriatus Schrad.
det. R. Carter 2004
Valdosta State University Herbarium (VSC)
BOTANICAL RESEARCH CENTER HERBARIUM (BRCH)
CYPERACEAE
TEXAS
Harris County
Cyperus diffusus M. H. Vahl
GPS - N29° 48' 24.0" W95° 25' 53.8" (NAD83)
26 July 2004
D.J. Rosen 3028

Houston. In the flood plain of White Oak Bayou, about 0.6 mi. SW of the intersection of Hwy. 610 and Ella Blvd.; a local green-space known as Little Thicket Park with about 7 acres of disturbed remnant riparian forest. Abundant rhizomatous herb apparently escaping from cultivation into shaded mesic slopes with *Carpinus, Prunus, Acer, Populus, Fraxinus,* and *Ulmus* spp.

Fig. 1. *Cyperus albostriatus* Schrad. (*Rosen 3028*—VSC 0006337)

spread species known from seaside and coastal habitats in the United States (Florida), southern Mexico, Central America, South America, Africa, Asia, Australia, and Islands in the Indian and Pacific Oceans (Kral 2002).

Fimbristylis cymosa is quite distinct from other Texas perennial *Fimbristylis* in its dense rosette of stiff, spreading excurved leaves and compact cluster of spikelets forming a corymbose head-like inflorescence. Koyama (1985) treated Ceylonese plants as *F. cymosa* subsp. *spathacea* (Roth) T. Koyama based on the presence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Fimbristylis cymosa R. Br. subsp. spathacea (Roth) T. Koyama
Det. David J. Rosen, 2012
Fimbristylis cymosa R. Br. subsp. cymosa
Det. David J. Rosen, 2011
CYPERACEAE
U.S.A., TEXAS
Cameron County
Fimbristylis cymosa R. Br
Padre Island: rare in vacant lot at the corner of Padre Blvd. and Mesquite
Alfred Richardson 3623
7 May, 2011
Ken King
HERBARIUM: THE UNIVERSITY OF TEXAS AT BROWNSVILLE

Fig. 2. ***Fimbristylis cymosa*** **R. Br. subsp.** ***spathacea*** **(Roth) T. Koyama (*A. Richardson & K. King 3623*—VSC 0006312)**

of biconvex achenes with bifid styles. As discussed by Kral (2002), New World specimens of *F. cymosa* (now including Texas plants) are bicarpellate with bifid styles and are thus treated here as *F. cymosa* subsp. *spathacea*.

Voucher specimen: **USA. Texas. Cameron Co.:** Padre Island; in vacant lot at the corner of Padre Blvd. and Mesquite, rare with *Calylophus serrulatus*, *Hedyotis nigricans*, *Linum lundellii*, *Rhynchospora colorata*, and *Spiranthes vernalis*, 7 May 2011, *A. Richardson & K. King 3623* (RUNYON, TEX, VSC). Fig. 2.

ACKNOWLEDGMENTS

We are grateful to Charles Bryson, Barney Lipscomb, and Gordon Tucker for reviewing this manuscript. The photographs were made possible through National Science Foundation award DBI-1054366 to Richard Carter, Valdosta State University. The second author (RC) kindly acknowledges support from his NSF grant.

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PHEMERANTHUS CALCARICUS (MONTIACEAE) NEW TO TEXAS

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ABSTRACT

Phemeranthus calcaricus is reported here as new to Texas. It was discovered in a limestone glade in Parker County, north of Weatherford, in a habitat similar to that in which is it found in Alabama, Kentucky, and Tennessee.

RESUMEN

Se cita aquí *Phemeranthus calcaricus* como nueva para Texas. Se descubrió en un claro de caliza en el condado de Parker County, al norte de Weatherford, en un hábitat similar al que se encuentra en Alabama, Kentucky, y Tennessee.

Phemeranthus calcaricus (Ware) Kiger (*Talinum calcaricum* Ware), limestone fameflower, is not listed by Diggs et al. (1999), but is present in Texas based on the key from the *Flora of North America* (Kiger 2004). *Phemeranthus calcaricus* was collected in Parker County, Texas, 10.2 km north and 3.3 km east of the Parker County Courthouse in Weatherford, in July of 2010 and May and September of 2011. *Phemeranthus calcaricus* is similar to *P. calycinus* (Engelm.) Kiger, which also occurs in north central Texas (Kiger 2004). Smaller sepal and petal size distinguish *P. calcaricus* (Fig. 1) from *P. calycinus* (Kiger 2004; Murdy & Carter 2001; Ware 1967). A summary of other distinguishing characteristics is provided for both species (Table 1).

According to Murdy and Carter (2001), based on chromosome number, *Phemeranthus calcaricus* may actually be an autotetraploid derivative of *P. calycinus*. *Phemeranthus calcaricus* has 24 pairs of chromosomes, whereas chromosome numbers of *P. calycinum* populations are either $n = 12$ or $n = 24$. *Phemeranthus calcaricus* and *P. calycinus* can hybridize and produce fertile offspring (Murdy & Carter 2001), but this should not be the case here due to lack of populations in the area of *P. calycinus*.

Phemeranthus calycinus is found in Southern Great Plains and Southern to South Central Plains regions. Specifically it is found from north central Nebraska, northeastern Colorado, and eastern New Mexico eastward to southwest Illinois, northeastern Arkansas, and north central Texas. *Phemeranthus calcaricus* is endemic to the Interior Low Plateaus physiographic province. Within this region, it is most abundant in the Nashville Basin of central Tennessee, the Moulton Valley of northern Alabama, and the Highland Rim of south-central Kentucky (Baskin & Baskin 2003; Kartesz 2011). Both species are found in similar habitats in glade-like open rocky soils, frequently associated with outcrops (Kiger 2004).

Phemeranthus calcaricus was previously thought to be endemic to limestone cedar glades of Tennessee, Alabama, and Kentucky; only one collection exists west of the Mississippi River from a glade in Arkansas [Izard Co.: ca. 4 mi W of Calico Rock, Limestone glades, 30 May 1976 *B.L. Lipscomb 1577*, NCU] This specimen was cited by Kiger (2004) but was not mapped by Kartesz (2011).

During field work for the "*Vascular flora of the north central Texas Walnut Formation*" (Swadek 2012), a population of *Phemeranthus calcaricus* was found on private property in Parker County, Texas, on a dry Walnut Limestone glade in full sun with thin, shallow, gravely clay loam entisols of the Maloterre Series (Greenwade et al. 1977; McGowen et al. 1987). Thus the geographical distribution of *P. calcaricus* now extends west into Texas (Fig. 2).

Herbarium specimens of *Phemeranthus* lose valuable taxonomic characters, e.g. petal size and color, fruit shape and size, and anther and style characteristics, as a result of pressing and drying (Holzinger 1900; Ware

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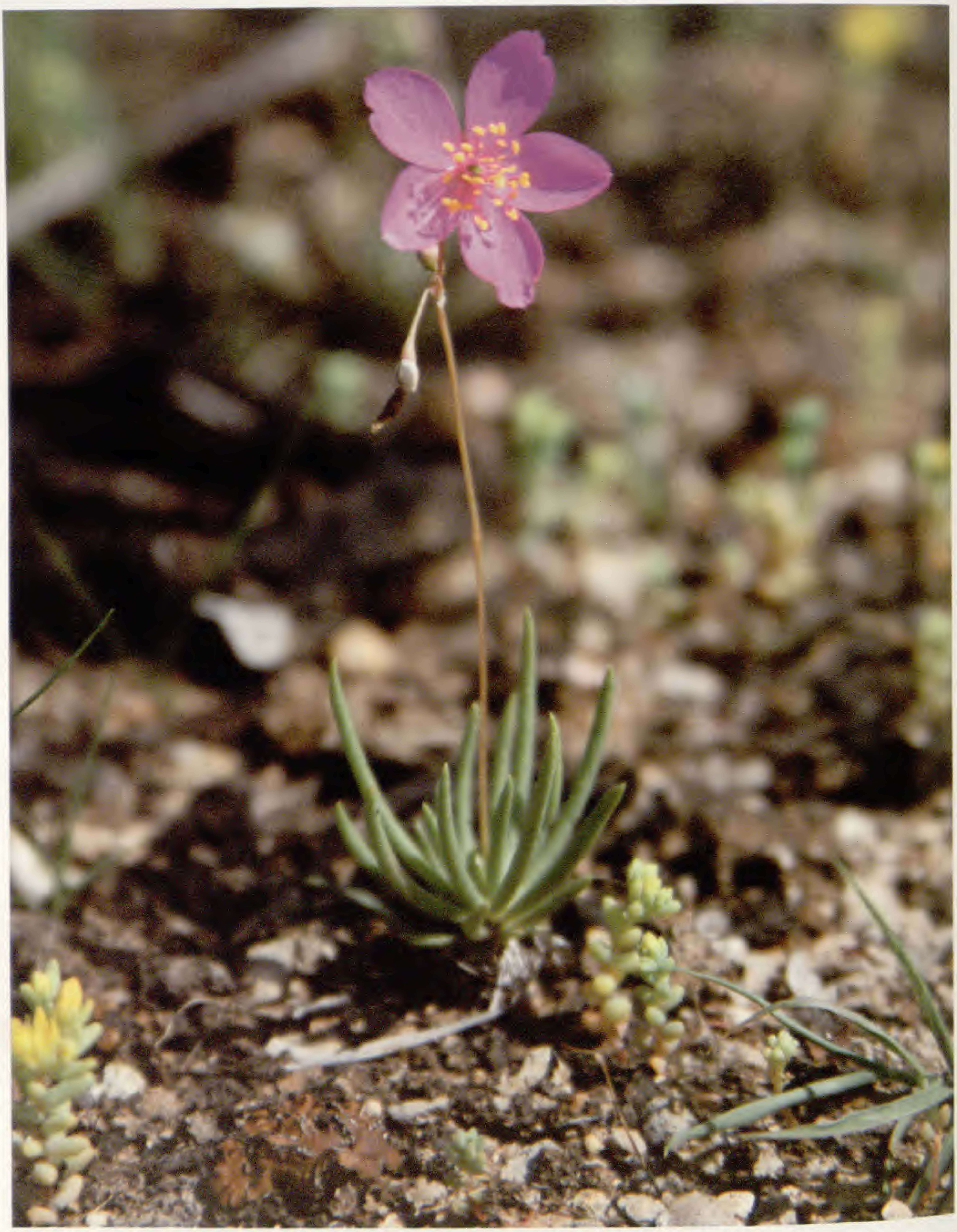

Fig. 1. *Phemeranthus calcaricus* in Walnut Glade north of Weatherford, Parker Texas, 18 May 2011, Rebecca K. Swadek.

Table 1. Distinguishing characteristics of *Phemeranthus calycinus* and *P. calcaricus* (Kiger 2004; Murdy & Carter 2001; Ware 1967).

Character	*Phemeranthus calycinus*	*Phemeranthus calcaricus*
Height	to 40 cm	to 25 cm
Roots	fleshy, woody	fleshy, tuberous
Inflorescence	cymose	cymose
Leaves	sessile, subterete	sessile, terete
Sepals	4–6 mm	3–4 mm
Petals	10–15 mm	8–10 mm
Stamens	25–45	25–45
Stigma	1	1
Capsules	6–7 mm	4–6 mm
Habitat	Limestone outcrops	Rocky to sandy soils, frequently on or near outcrops

1967). Living specimens were also examined in the field to determine morphological characteristics. Additionally, some plants were transplanted to pots and shallow saucers in a backyard, with similar climate, and differing soil mediums (native, half native and half commercial medium). Transplants received only rainwater and were observed over the course of two years in order to further evaluate the morphological variation. Though this was not a thorough study, it should still be noted that soil medium does have some affect on phenotypic plasticity—plants grow taller and flower earlier in a partly commercial medium than those in native soil, but there is no difference in sepal size. This slight plasticity may be why these two species are so difficult to differentiate and this matter probably deserves further study. Other specimens in the BRIT-SMU-VDB herbarium due key to *Phemeranthus calcaricus* from *P. calycinus*, but due to the difficulties in identifying the species following pressing and drying, and differing habitats and soil mediums, the identity of those specimens is still left to speculation.

Voucher specimens: **U.S.A. TEXAS. Parker Co.:** Walnut Limestone glade at Utley Prairie, shallow gravelly clay loam weathered from limestone of the Maloterre Series, ca. 7 mi N of Weatherford, W of FM 51 at ca. 5130 Weiland Road, 32.8664 N, -97.7614 W, 14 Jul 2010, *R.K. Swadek 387* (BRIT); 18 May 2011, *R.K Swadek 625* (BRIT); Walnut Limestone glade at Utley Prairie, shallow gravelly clay loam weathered from limestone of the Maloterre Series, ca. 7 mi N of Weatherford, W of FM 51 at ca. 5130 Weiland Road, 32.85091 N, -97.76230 W, 28 Sep 2011, *R.K. Swadek 746* (BRIT).

Glades of the Walnut Limestone geological formation are open expanses of rock surrounded by shallow soiled barrens and limestone scrub woodlands. Though the habitat is structurally similar to limestone cedar glades of the southeastern United States, those of the north central Texas differ in that *Juniperus virginiana* L. is not dominant. The population of *Phemeranthus calcaricus* found in North Central Texas is associated with *Dalea reverchonii* (S. Wats) Shinners (a north central Texas limestone glade endemic), *Minuartia michauxii* var. *texana* (B.L. Rob.) Mattf., *Sedum nuttallianum* Raf., and a cyanobacterium, *Nostoc commune*. Nearby in adjacent barrens—often called xeric limestone prairies, which are slightly deeper soiled and frequently slightly sloping—the dominant vegetation includes *Opuntia phaeacantha* Engelm., *Yucca pallida* McKelvey as well as various perennial bunch grasses such as *Aristida purpurea* Nutt. var. *nealleyi* (Vasey) Allred, *Schizachyrium scoparium* (Michx) Nash, and *Tridens muticus* (Torr.) Nash. The scrub woodlands adjacent to these glades and barrens are dominated by *Celtis laevigata* Willd., *Forestiera pubescens* Nutt., *Quercus* spp. (*Q. buckleyi* Nixon & Dorr, *Q. fusiformis* Small, or *Q. sinuata* Walter var. *breviloba* (Torr.) C.H. Mull.), and *Rhus trilobata* Nutt. This description is very similar to a community described by Quarterman (1950) with *Celtis laevigata, Forestiera ligustrina* (Michx.) Poir., *Petalostemum gattengeri* (now *Dalea*), *Rhus aromatica* Aiton, *Sedum pulchellum* Michx., and *Talinum teretifolium* Pursh (now possibly *Phemeranthus calcaricus*, as it was not described until 1967), on a limestone glade in Tennessee.

Gratiola quartermaniae D. Estes and Small, previously reported from central Texas in Bell, Llano, and Williamson counties and eastern limestone cedar glades (Estes & Small 2007) was also discovered on Walnut Glade seeps in north central Texas (Taylor & O'Kennon, in prep.). Though approximately 1,200 km apart, Walnut Limestone glades and Southeastern limestone cedar glades have remarkably similar structural and

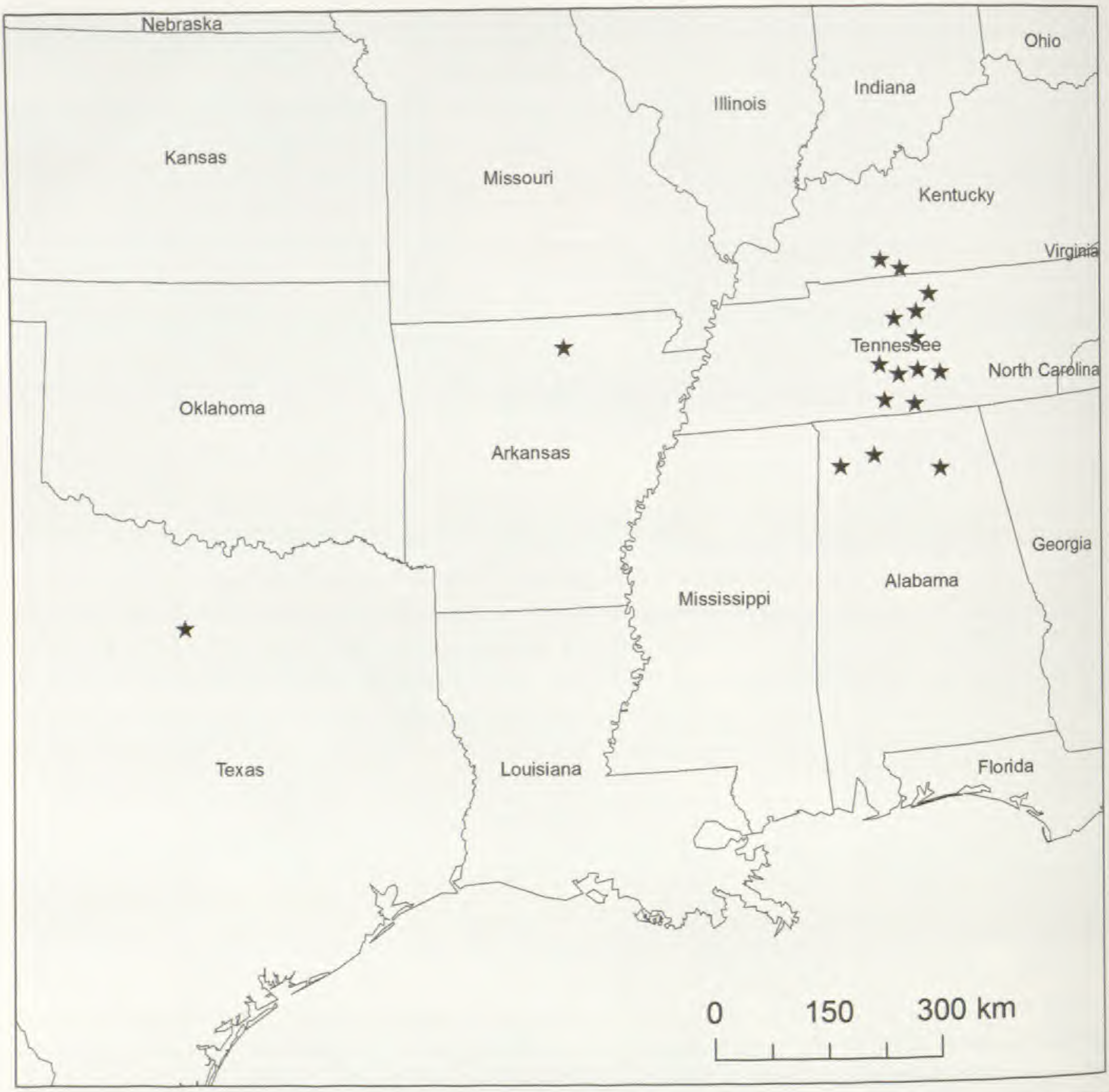
Nebraska
Kansas
Missouri
Illinois
Indiana
Ohio
Kentucky
Virginia
Tennessee
North Carolina
Oklahoma
Arkansas
Mississippi
Alabama
Georgia
Texas
Louisiana
Florida
0 150 300 km

Fig. 2. Known geographic distribution of *Phemeranthus calcaricus* in North America.

floristic qualities. Some species common to both glade systems include *Croton monanthogynus* Michx., *Dichanthelium acuminatum* (Sw.) Gould & C.A. Clark, *Gratiola quartermaniae, Hedyotis nigricans* (Lam.) Fosberg, *Heliotropium tenellum* (Nutt.) Torr., *Isoëtes butleri* Engelm., *Nostoc commune, Nothoscordum bivalve* (L.) Britton, *Oenothera macrocarpa* Nutt., and *Sporobolus vaginiflorus* (Torr. ex A. Gray) Alph. Wood.

Many species found in Walnut Glades are related to those of Eastern Limestone Cedar Glades. These species live in similar habitats, likely fill the same ecological niches, and have evolved similar traits. Related species include *Dalea gattengeri* (A. Heller) Barneby on cedar glades versus *D. reverchonii* and *D. tenuis* (J.M. Coult.) Shinners on the Walnut Formation, *Eleocharis bifida* S.G. Sm. versus *E. occulta* S.G. Sm. and *E. montevidensis* Kunth, *Minuartia patula* (Michx.) Mattf. versus *M. michauxii* var. *texana, Opuntia caespitosa* Raf., formerly thought to be *O. humifusa* (Raf.) Raf. (Majure et al. 2012), versus *O. phaeacantha*, and *Sedum pulchellum* versus *S. nuttallianum* (Baskin & Baskin 2003; Jones 2005; Norton 2010; Quarterman 1950).

Images of the voucher specimens are available at BRIT's online digital herbarium, Atrium (atrium.brit.org) or http://atrium.brit.org/search.php?q=phemeranthus&x=0&y =0&query=all.

ACKNOWLEDGMENTS

I would like to thank David Utley for allowing me to collect on his property for the last several years. I would also like to thank Barney Lipscomb for his encouragement, and Amanda Neill, Art Busbey, and Tony Burgess for their reviews and support during the course of my master's thesis.

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BOOK REVIEW

Douglas F. Welsh. 2011. **Doug Welsh's Texas Garden Almanac.** (978-1-60344-478-1 (flexbound with flaps). Texas A&M University Press, John H. Lindsey Building, Lewis Street, 4354 TAMU, College Station, Texas 77843-4354, U.S.A. (**Orders:** www.tamupress.com, 800-826-8911). $24.95, 492 pp., 8.5" × 11".

In his book, *Texas Garden Almanac*, Doug Welsh offers us a wonderful month-by-month guide to gardening in Texas. Welsh's years of experience as Professor and Associate Department Head of Horticulture with the Texas AgriLife Extension Service, along with 21 years as the Statewide Coordinator for the Texas Master Gardener program, provides Texas gardeners and "yardeners" with a wealth of in-depth knowledge and information on what it takes to garden in Texas.

The book offers advice in a clear, concise, easy-to-read format. Welsh encourages you to "think like a plant" to understand a plant's functions and to observe and anticipate its needs. He offers advice for those tending rose, vegetable and/or container gardens; for those planting native flowers, lawn grasses and trees, shrubs or vines; and for those improving soils and pruning plants. It is all here in a step-by-step, easy-to-use guide.

Chapters are laid out by month, each opening with a "mini" table of contents. Within each chapter are information boxes on timely topics such as garden design, colors and wildflower seeds; selected plant lists for vegetables, wildflowers, roses, trees, etc.; and short essays on specific topics such as pests or irrigation. Additionally, Welsh includes Q&A boxes covering a variety of questions he has received from the public as a call-in radio show host. Each chapter concludes with "Timely Tips" for the month. Lively illustrations by Aletha St. Romain enrich the book with colorful drawings of flowers, wildlife, trees, grasses, and insects as well as topic icons which direct the reader to specific subjects.

Welsh's book landed on my desk just in the nick of time as my daughter and I were developing plans for our first vegetable garden. Being relatively new to Texas, and a "yardener" on the verge of up scaling to a gardener, this has been my go-to resource book this spring. I have turned to it for advice on planting times, watering, developing vegetable and butterfly gardens and more. So now … let me turn to July and read up on gardening tips to survive the "Dogs Days of Summer."

—Gwen Michele Thomas, Texas Master Naturalist & Volunteer, Botanical Research Institute of Texas, 1700 University Dr., Fort Worth, Texas 76107-3400, U.S.A.

OSVALDO MORRONE
(11 DEC 1957–18 OCT 2011)

Liliana M. Giussani

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After Osvaldo's passing, I, as his wife and collaborator, received so many heartfelt words from friends, family, and colleagues, which comforted me after such a difficult and sad time. First of all, I need to thank everyone for their love and kindness.

Osvaldo, only 53 years old, was recognized by the botanical society for all his contributions during a short but significant career. I invite those who want to learn details of his contributions to take a look at the issue of Darwiniana 49(2):257–262. 2011. In addition, an intimate glimpse into his personality, as seen by his friends Fernando Zuloaga and Elizabeth "Toby" Kellogg, can be seen in the following links:

http://www.ojs.darwin.edu.ar/index.php/darwiniana/article/view/326/318 and
http://www.aspt.net/publications/newsletter/in_memoriam.php, respectively.

He obtained his Bachelor's degree in Natural Sciences at the Universidad Nacional de La Plata (UNLP-Argentina) and received his Ph.D. in Natural Sciences, in 1989. As a post-doc he was a research fellow of the National Museum of Natural History, Smithsonian Institution in Washington; the Missouri Botanical Garden in St. Louis; and the John Simon Guggenheim Memorial Foundation, USA. He was employed by the CONICET-Argentina where he became Principal Scientific Researcher, working at the Instituto de Botánica Darwinion. There, he was also involved as subdirector.

He developed various research areas at the Instituto Darwinion, and completed significant manuscripts; he also directed several theses. He contributed to the formation of many students who were trained in the taxonomy and systematics of different genera of the family Poaceae, as well as additional plant groups like orchids. Among the students he mentored, who are now developing a research career, are: Maria Amelia Chemisquy, Diego De Gennaro, Diego Giraldo Cañas, Silvia S. Denham, Sabina Donadío, Hugo Gutierrez, Verónica Kern, Nataly O'Leary, Alicia López, Diego L. Salariato, and others. Since 2004, Osvaldo and I were particularly involved in many research projects in molecular systematics at the Darwinion Institute. Being so close to him, I had the advantage of learning from his expertise, and his way of appreciating plant science.

At the end of his career, Osvaldo collaborated on the recent contribution to the Poaceae phylogeny with the GPWGII, in New Phytologist, 2012, and accomplished significant work on the re-classification of the tribe Paniceae (Poaceae); Morrone et al., in Cladistics, 2012 (28, no. 4, pp. 333–356, August). This work not only represents his taxonomic and evolutionary knowledge and expertise on this panicoid tribe, but also the unconditional support of his working group. For all those people who were so close to him during these four years in which he battled cancer, Osvaldo was a role model and a living example of happiness, friendship, and professional work. To everyone involved, I express a sincere thank you for being so close to him.

Osvaldo's other major contributions were close to completion and will soon be finished, including the phylogeny of *Nassella* and allies, the phylogeny of *Paspalum*, a revision of the Old World *Setaria*, the biogeography of Poaceae, and the contribution to the Chilean Flora. Several contributions that are still awaiting publication represent collaborative projects with colleagues in different working lines, namely Rob Soreng and Paul Peterson, Fernando Zuloaga, Elizabeth "Toby" Kellogg, and Pilar Catalán. Although he benefitted greatly from

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Osvaldo Morrone collecting *Bipinnula montana* Arechav. (Orchidaceae) in Uruguay (Depto. Minas, Cerro Verdum, Morrone & Giussani, 6316, SI) in October 2010. Photo by Lilliana Giussani.

their expertise, he put even greater value on their friendship. I offer a special thank you to Pilar, for such a wonderful and productive time in Spain.

I consider myself enormously lucky for having met Osvaldo and fallen in love with him. We had a beautiful son and shared a life, family, friends, and our profession. I would like to give special thanks to other friends who made a difference in his life and shared unforgettable moments, especially to Horacio, Patri, Pichi, Dundi, Fernanda, Gus, Marieta, Mario, Guille, Silvana, Javier, Pablo, Ani, Lili, Normi, and all Darwinion friends, family and children.

Other personal memories will stay in my heart.

EDWARD GROESBECK VOSS
(1929–2012)

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Edward Groesbeck Voss, Professor and Curator Emeritus at the University of Michigan Department of Ecology and Evolutionary Biology and University of Michigan Herbarium died on February 13, 2012 at his home in Ann Arbor, Michigan, U.S.A. after a brief illness. He was born on February 22, 1929 in Delaware, Ohio, U.S.A, and after attending Woodward High School (class of 1946) in Toledo, Ohio, he completed his education with a bachelor's degree with honors from Denison University (1950), and a master's in Biology (1951) and a doctoral degree in Botany (1954), both from the University of Michigan. He was awarded an honorary Doctor of Science from Denison University in 2003.

He began his long association with the University of Michigan Herbarium in 1956, appointed as a research associate beginning a five-year project to document the flora of Michigan. He joined the Botany faculty in 1960 as assistant professor and was promoted to associate professor (1963), and professor (1969). He continued his painstakingly precise study of the flora of Michigan, culminating 40 years later with the appearance of the third volume of the Michigan Flora in 1996; the same year that he retired and was granted Professor Emeritus status. He also served as Curator of Vascular Plants at the Herbarium from 1961 until his retirement in 1996; he continued to work at the herbarium until late in 2011.

In addition to his work on the flora of Michigan, Ed also actively studied Lepidoptera of the northern Great Lakes area, taught at the University of Michigan Biological Station (UMBS) for 36 summers, and was an

Ed Voss taking a lunch break amidst the lichens of northern Michigan. Photo by John Russell.

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astute student of botanical nomenclature. Readers of *J. BRIT* may likely be familiar with this last aspect of his work. His skills in this area no doubt benefitted from his father having taught Greek and Latin and imparting in Ed a deep appreciation for precise linguistics. Ed's plant nomenclature activities were largely focused via service on the General and Editorial Committees responsible for the revision of the *International Code of Botanical Nomenclature*. He was a member of the Editorial Committee from 1969 to 1993 (i.e., from the Seattle to the Berlin Codes), served as the Secretary of the Committee for the Seattle and Leningrad Codes, and Chair for the Sydney Code.

He also shared several similarities with Lloyd Shinners, the founder of *Sida*, the predecessor to *J. BRIT*. Ed would likely have first met Lloyd at UMBS, where Ed served as a teaching assistant for Lloyd when he taught Systematics in 1952. Ed described himself as "an admirer of Lloyd Shinners" and they "carried on a correspondence for the next 17 years" (letters of E.G. Voss to B. Lipscomb). He cited Lloyd's help with determinations of Asteraceae in his 1957 publication on new records in the flora of Michigan. Neither Ed nor Lloyd ever married, likely allowing them to devote themselves more singularly to the botanical passion that drove both men. Both went on to found and edit scientific journals, curiously both appeared in 1962. Ed founded and edited the first 15 volumes of *The Michigan Botanist*, the scientific journal of the Michigan Botanical Club focusing on botany of Michigan and the Great Lakes region, and served on the Editorial Board until his death. Only one of Ed's many publications appeared in *Sida*; a review of *Webster's Third New International Dictionary of the English Language, Unabridged Edition in 1964*. Both had a strong interest in books; Ed's personal library numbered into the thousands of volumes and included many rare items, much as what Lloyd accumulated that would later form the basis of the BRIT collection.

A series of articles about the various facets of Ed's life will appear in *The Michigan Botanist* later this year.

GERALDINE ELLIS WATSON
(8 FEB 1925–6 APR 2012)

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Geraldine Ellis Watson (Fig. 1), artist, botanist, writer, conservationist, colleague, friend, and one of the individuals responsible for creation of the Big Thicket National Preserve, died on 6 April 2012. She was born February 8, 1925 in Bon Ami, Louisiana to Herbert Guy Ellis and Retha Goznell Ellis (Houston Chronicle 2012). She lived near Silsbee and maintained the Watson Pinelands Preserve (Tyler Co.), dedicated to preserving a portion of the diversity of the Big Thicket. She is survived by four children, Marvin E. Watson, Bobby L. Watson, Retha Regina Watson, Maria Eden Williams, four grandchildren, and six great grand children.

Watson devoted much of her life to protecting the Big Thicket. Her efforts included identifying and collecting plants for the University of Texas at Austin and the National Park Service, her many publications (e.g., Watson 1975, 1979, 1982, 2003, 2006), her political involvement with the Big Thicket Association for the creation of a federal preserve, her input in establishing the most appropriate boundaries for the new federal preserve, and her work restoring a portion of the Thicket on the Watson Pinelands Preserve near Warren (Diggs, Lipscomb, Reed, & O'Kennon 2006; Dembling 2012).

I (B.L.L.) met Geraldine in the early 1980s after the establishment of the Big Thicket National Preserve in 1974 with my colleague Wm. F. (Bill) Mahler. Bill and I (during our SMU days) visited and botanized with Geraldine on a number of field trips. Later (2000–2006), while working on the *Illustrated Flora of East Texas*, my colleague George and I enjoyed visits with Geraldine at her Watson Pinelands Preserve on a number of occasions. Geraldine cooperated with us and assisted us in a number of ways in our work on the East Texas flora. She painted the frontispiece to the introduction of the *Illustrated Flora of East Texas, Volume 1*, allowed access to the Watson Pinelands Preserve, and contributed a variety of information on the Big Thicket. Our last visit (2005) with Geraldine was memorable with reminiscing conversation and good tea in her home on the Preserve. After tea and a visit, Geraldine proudly walked around the Preserve pointing out to us her favorite plants and telling stories. It was easy to see and understand why Geraldine loved the Big Thicket. Gracious as always, Geraldine was thrilled to receive a copy of the *Illustrated Flora of East Texas, Volume 1* at a book signing event at Stephen F. Austin State University, Nacogdoches (Fig. 2).

For more information about Geraldine and to see two of her paintings (*Alophia drummondi*, p. 267; *Cypripedium kentuckiense*, p. 320), see pp. 194–196, 264–267, and 320 in Diggs, Lipscomb, Reed, & O'Kennon 2006). See online at www.brit.org/sites/default/files/public/BRIT%20Press/IFNCT_Docs/SBM_26_pp1_272.pdf and www.brit.org/sites/default/files/public/BRIT%20Press/IFNCT_Docs/SBM_26-pp309-1151.pdf.

A video interview of Geraldine (from 1999) can be found on-line at the Texas Legacy Project (2009b) and a transcript of the interview can be seen at the Texas Legacy Project (2009a). She was one of 62 pivotal Texas conservationists chosen to be included in the book, *The Texas Legacy Project: Stories of Courage and Conservation* (Todd & Weisman 2010). For an article about Geraldine published just before her death, see Kabele (2012).

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Fig. 1. Geraldine Watson. A photo of a younger Geraldine and one in particular that she liked. *Illustrated Flora of East Texas, Volume 1,* Fig. 113, p. 194 (Diggs, Lipscomb, Reed, & O'Kennon 2006).

Fig. 2. Geraldine Watson with Barney Lipscomb at Stephen F. Austin State University, 30 Mar 2007. Photo taken at a book signing for the *Illustrated Flora of East Texas, Volume 1.*

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BOOK REVIEWS

V. Bhaskar, V. 2012. **Taxonomic Monograph on *Impatiens* L. (Balsaminaceae) of Western Ghats, South India: The Key Genus for Endemism.** (ISBN: 978-935067-257-0, pbk.). Centre for Plant Taxonomic Studies, 'Udayaravi', 2nd Main Road, Cholanagar, R.T. Nagar P.O., Bangalore – 560 032, INDIA. (**Orders:** vbhaskar49@yahoo.co.in). $200.00, 283 pp., 4 tables, 173 plates.

The members of the genus *Impatiens* (*Balsaminaceae*) are popularly called balsams or jewel weeds. They are also referred to as 'orchid flowers' as their flowers resemble those of orchids. Several species and their hybrids are grown as prized ornamentals and are in great demand throughout the world because of their vivid colors. Taxonomically, the genus encompasses very difficult groups of plants to classify. After his monumental publication *The Flora of British India*, Sir J.D. Hooker returned to work on Impatiens because he found tremendous diversity in this genus. The work classified approximately one hundred and twenty-three species of *Impatiens*. However, the author was unsatisfied with his treatment and left a number of open ends for which he could not come to any conclusion.

This taxonomic monograph on *Impatiens* of Western Ghats provides a comprehensive treatment of 106 species and 13 varieties occurring in the richly biodiverse Western Ghats region. Fifteen new species and six new varieties described by the author himself are included. Taxonomic key for identification is provided to seven sections (formed by Hooker & Thomson 1860) with separate identification keys for species under each section. The author has resurrected *I. bababudenensis* Hook.f. which was synonymised under *I. latifolia* by J.S. Gamble. This seems quite logical as the former has $n=6$ and the latter has $n=3$ chromosome numbers, apart from other morphological differences between the two. Similarly, *I. fasciculata* (Lam.) has been resurrected as an independent species, and *I. chinensis* var. *brevicornis* Barnes has been elevated to specific level.

The most useful information provided by the author is the micro-morphological characters. These include various kinds of banding pattern of testa indumenta in brown-seeded species, pollen morphological characters, chromosome numbers for a majority of species, and, in a few cases, embryo sac type and anatomical characters. A consolidated summary on the chromosome numbers and pollen morphological characters reported by the author as well as other authors is also provided. The plate(s) provided for each of the species depicts photos of both morphological and micro-morphological characters which readily help one to immediately capture the striking characteristics of the species. The display of dissected floral parts, provided for most of the species, is another important aspect which was very much required for this genus. A case study on autecology of *Impatiens acaulis – I. scapiflora* complex has been well presented, clearly showing how the plant populations vary greatly from population to population, especially with regard to leaf morphology, flower color, spur length, and wing petals. The author rightly recognizes that stable qualitative traits should only be considered while describing new species.

There is handy information on the range of distribution of each species in the Western Ghats as well as the names of species collected from each of the hill ranges in the region. The author has ably attempted to discuss endemism and affinities, and also origin and evolution of *Impatiens* of Western Ghats. He believes that the occurrence of lower chromosome numbers of $2n=6$ or $n=3$ and larger chromosomes as in the case of *I. leschenaultii* and *I. latifolia* occurring in the Nilgiris Mountains and the second lowest chromosome number of $2n=12$ or $n=6$ as in the case of *I. talbotii*, *I. pulcherrima*, and *I. bababudenensis* in the northern part of Western Ghats, is clear proof of the primitiveness of Western Ghats species. The author has tried to correlate the type of seed: horny seed and brown seeded seeds with testa indumenta, with endemicity and distribution of *Impatiens* species in Western Ghats. However, he finds no impact as the extent of endemism between these two categories of species is more or less the same.

Finally, the author has categorized the species of *Impatiens* reported in Western Ghats according to their threat status. He believes that 7 species are possibly extinct, 40 species fall under the category of critically endangered, 33 under the category of endangered, and 16 are under vulnerable status. These conclusions certainly warrant immediately undertaking stringent measures to protect natural balsam growing habitats. It is also essential to undertake species rehabilitation programs to prevent extinction of endangered species. Another important contribution in this work, apart from the other original material, is the simple low cost technique of 'drip and splash method' which the author has developed to cultivate wild balsams in the greenhouse. This will definitely help to grow practically all balsams with ease for either research or ex-situ conservation.

This work deviates in the presentation of text and illustrations when compared to conventional taxonomic monographs; perhaps the author intentionally structured his work this way in order to break the monotony and make it user friendly. It would have been better if the author had followed the latest and standard nomenclatural norms and carried out better editing of the text before sending the manuscript to press, since lapses are found sporadically in the book. However, there is ample scope to improve the running text as well as to reduce the size of the book by printing plates back to back in the next edition.

Nevertheless, the author has done a commendable job and has produced an excellent piece of work on *Impatiens* of Western Ghats. I am strongly of the opinion that this type of monograph is needed for all the genera. Indeed, the author has set a model for future taxonomists who would like to take up monographic work on various groups of plants. I am sure it will greatly assist in correct identification as well as emphasizing the importance of using various other micro-morphological characters as supplementary traits in future monographic works. Though the book is priced on a no loss no profit basis, still the price is prohibitive and many individuals could not afford to own this book. However, it will be a good reference book in institutions engaged particularly in taxonomic research. On the whole, no monetary value can compensate for the amount of work and passion that has gone into this valuable monograph.

—S.N. Yoganarasimhan, Ph.D., FBS, FIAAT, Retired Head, Medicinal Plants Division, Regional Research Centre (Ay), Govt. of India, Bangalore. Presently Visiting Professor & Research Co-coordinator, Dept. of Pharmacognosy, M.S. Ramaiah College of Pharmacy, Bangalore 560058, INDIA, Email: seekyogan65@yahoo.in

Robert P. Adams. 2011. **Junipers of the World: The Genus *Juniperus*, Third Edition.** (ISBN: 978-1-4269-5382-8 (sc) pbk., Print-On-Demand). Trafford Publishing Co., 1663 Liberty Drive, Bloomington, Indiana, 47403, U.S.A. (**Orders:** www.trafford.com, www.juniperus.org, 1-888-232-4444). $29.95, 426 pp., b/w photos, illustrations, 8" × 11".

Robert Adams has devoted his entire academic career to the study of the genus *Juniperus* from graduate school days at the University of Texas beginning in 1966 until more recently at Baylor University where he is Professor of Biology. It is rare indeed for an author to reap the benefits of a concentrated study on any subject throughout their professional academic career that results in a book that is a masterpiece.

More evidence for this comprehensive treatment can be found in the Literature Cited that includes 118 papers published by Adams as part of a total of 373 mostly related to the taxonomy, nomenclature and identification of 67 species, 37 varieties 7 formas of Junipers. Additional information on evolution, ecology, geographic distribution and variation, phylogenetics based on DNA data and analysis with phylograms, cultivation and commercial uses of wood and wood products, especially the essential oils, provide an in-depth record of the biology of Junipers. This comprehensive listing of books and journal papers that covers 13 pages (368–382) will serve the user as a rich source of information about Junipers.

The book contents are organized into 11 chapters: Introduction; Geographic Variation; Speciation in sections of the genus; Keys to Junipers; Species Description, Distribution Maps and Plant Photos; Hybridization; Ecology; Seed Dispersal in *Juniperus*; Sex Expression in *Juniperus*; Cultivated Junipers; Commercial Use of Leaf and Wood Oil of *Juniperus*. A glossary of defined terminology was not included that would have made the morphological structures described in the species descriptions more easily understood and the key characters employed in the identification keys more user friendly, especially for an audience who may have a more broader interest in conifers. A general classification of conifers, including the Junipers, would help give the reader evolutionary context for the phylogenetic relationships at ranks above the generic level.

Line drawing illustrations, maps, and tables are clear and distinct. Landscape, habit, morphological, and general interest black and white photographs number more than 700 of various sizes usually two to four per page. Unfortunately many of these photographic images appear washed out and lack detail because of resolution problems either due to the poor quality of the paper print, scanning pixels per inch, or both. There is not a subject index with pagination that guides the reader to specific information throughout the text.

The introduction includes the description of the leaves, cones, and the division into three sections with the characters compared in Table 1.1. All of the *Juniperus* taxa except one are found in the Northern Hemisphere and maps show this distributional geographic pattern. Bayesian Trees based on nr DNA (ITS) and cp trnC-trnD sequences serve to separate taxa into sections and clades so taxonomic decisions are supported by sequence data.

Geographic variation in *J. communis* is documented for the only species found in both the eastern and western hemispheres. Geographic colonization, migration pathways, and distributional patterns are traced during the last ice age (5,000 to 10,000 BP years ago). Collections made throughout the world along with DNA analysis, morphology, and physiological data result in the recognition of seven varieties. *Juniperus ashei* occurs on millions of acres of limestone outcrops from central Texas through the Ozarks. Additional migration patterns were traced for *J. procera*, the only species that grows in the southern hemisphere from Arabia into east Africa. Infraspecific variation in *J. phoenicea* and its infraspecific taxa was based on leaf essential oils using DNA fingerprints, RAPD (random amplification of polymorphic DNA) markers. Geographic variation in *J. polycarpos*, monospermous junipers of the Chihuahuan desert, *J. thurifera*, and *J. virginiana* complete this section.

Keys to *Juniperus* species and varieties are arranged geographically into the Eastern Hemisphere, into Europe, Canary Islands, Azores, Asia Minor and Africa, into Central Asia, into China Himalayas, Mongolia, Russia, and Korea, into the Far East (Japan, Taiwan, Sakhalin Island), into Continental North America, into Canada and the United States of America, into Mexico and Guatemala, and into Caribbean Junipers. Obviously a species such as *J. communis* will appear in more than one key. These dichotomous keys are numbered, indented and based on paired couplets of usually one, two or three characters but are sometimes rather long descriptive statements. The leads are sometimes separated by several pages, extend up to 39 couplets, and are not reversible.

Species Descriptions, Distribution Maps and Photos are provided for all of the taxa included in the book. An added feature is the inclusion of the status of each taxon category, for example, critically endangered, endangered, and vulnerable among others. Each species description has the following categories in boldface: Dioecious/monoecious, Trunk bark, Branches, Leaves, Seed cones, Seeds, Pollen shed, Habitat, Uses, Dist., and Status. The majority of the book is devoted to this section from pages 101 to 327.

My comments on species descriptions will be confined to *J. virginiana* var. *virginiana* (Eastern Red Cedar although it is not a true cedar) as an example since I have collected fungi, corticolous myxomycetes and bark samples from this species for more than 45 years throughout the Southeastern and Midwestern U.S.A. Beauty is in the eye of the beholder, but this taxon has a special beauty highlighted by a conical or pyramidal shape, deep green leaves that remain evergreen, and the fleshy, bright, blue berrylike cones of the female trees. Cemeteries located throughout the central and southeastern United States of America often had *J. virginiana* var. *virginiana* trees, sometimes to the exclusion of other tree species. Apparently *J. virginiana* was planted near gravesites because it was readily available as a native tree species, it grew well in open field areas in full sun, and symbolically was considered the "death tree." The photographic black and white images do not do justice to the attractive plantings and landscapes of this taxon. One image in particular Figure 7.15 shows this taxon along a fence row where birds have roosted and excreted "planted" seeds. I have seen this fence row growth pattern in a number of different places. While a graduate student at the University of Kansas in Snow Hall I observed hundreds of cedar wax wings birds congregating in a female Eastern Red Cedar tree apparently feeding on the fleshy cones. Another interesting use of Eastern Red Cedar is as a tree species in shelterbelts in Western Kansas. Many of these were planted in the 1930s during the dust bowl years. This is a hardy tree that tolerates cold and hot temperature extremes and provides wildlife habitat especially for pheasants, reduces wind velocity (windbreak) against soil erosion and loss of moisture from soil, provides shade for buildings nearby, and protects farm livestock and gardens from exposure to weather extremes. This should have been included as a major use of this tree species.

Juniperus virginiana var. *virginiana* is the primary host for the cedar-apple rust fungal pathogen, *Gymnosporangium juniperi-virginianae*. Many other species of *Juniperus* can also serve as the host of this destructive fungal pathogen that also have as an alternate host *Malus* (apple trees). The photographic image (page 324) shows the reddish-brown, hard, bodies about the size of a pecan attached to the Juniper twigs that are sometimes confused with insect galls. In April and May after prolonged rainy periods these galls swell in size and appear as a gelatinous, bright orange ball with long horns. Heavy infestations of the rust fungus result in trees decorated with balls that appear much like Christmas tree ornaments. The telial horns produce teliospores that germinate into basidiospores eventually transported by wind to apple trees several miles nearby. The growth of the fungus forms unsightly lesions on apple leaves and fruit that eventually can result in significant economic loss due to the decline in apple production. The removal or controlled planting of these trees is essential to break the disease cycle of this plant pathogen.

The chapter on Ecology emphasizes the occurrence of *Juniperus* species on limestone escarpments, sand dunes, sphagnum bogs and swamps, the margins of deserts, and invading the tall grass, deep, blackland soils in central Texas as for example *J. ashei*. Species of *Juniperus* in the Midwest are weedy and in prairie habitats aggressively invade open fields becoming a nuisance and cause for removal.

Seed dispersal in *Juniperus* is a chapter that highlights the role that birds play in feeding on the fleshy seed cones and serve as the main dispersal source over longer distances. Figure 8.1 is a graphic flow chart of agents, percentages, and distances of seed dispersal. Mammal species are also involved in seed dispersal and germination experiments show that intestinal passage significantly improves germination in most cases. Harvester ants also form marching columns to Juniper trees on a daily bases then carry back the female cones some distance to their underground ant nests.

Sexual expression in *Juniperus* is in the majority of species dioecious but a few trees that are predominately male trees produce a few female cones and the opposite is also true. *Juniperus osteosperma* is the exception with 85 to 90% of the trees monecious (both male and female cones on the same tree). The author's observations that environmental stress, such as xeric sites or trauma caused by a broken branch, may induce either male or female cones suggest external factors also play a role in maleness or femaleness.

The Commercial Use of Junipers is a must read chapter to fully appreciate how byproducts such as cedarwood oil and cedarwood is used. A table of heartwood oils with percentages of chemical components such as cuparene, decrol, and widdrol is recorded in different species of Junipers. There is a section on cedarwood oil extraction in Texas that shows truck loads of *J. ashei* transported to commercial extraction plants in the central Texas area and a discussion of extraction processes. Cedarwood chips are sold commercially and used around houses to repel insects. The insecticidal properties of cedar wood are active against a wide spectrum of insects including German cockroaches, moths, ants, and termites hence the use of Junipers that has a natural preservative for fence posts or lining cedar chests and closets where clothes are stored. Although not mentioned in the book cedarwood was used to make wooden pencils. Indeed a pencil factory was located at Cedar Key, Florida where a museum documents the extensive logging of cedar trees in combination with hurricanes that led to the decimation of the trees that once grew abundantly in the area.

This book is not without shortcomings but the content deserves special recognition as a scholarly publication worthy of the designation as a classical piece of scientific literature. Travel to faraway places throughout the world to collect specimens, use of the modern techniques of DNA analysis, use of terpene and essential oil chemistry, and the traditional use of morphological characters and the type method add to the scientific value of the narrative. Persons interested in conifers will appreciate the most up to date authoritative reference on Junipers. College, university, and public libraries will want to have this affordable book available to the general public to enjoy the biodiversity of Junipers. This book should be purchased because of the bargain basement price and information useful to botanists and botanical gardens, foresters, herbaria, landscape nurseries, museums, nature and state conservation agencies, rangeland and wildlife managers, and state and national parks.

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STEVEN H.D. HADDOCK AND CASEY W. DUNN. 2011. **Practical Computing for Biologists.** (ISBN: 978-0-87893-391-4, pbk.). Sinauer Associates, Inc., Publishers, 23 Plumtree Road P.O. Box 407 Sunderland, MA 01375-0407 U.S.A. (**Orders:** www.sinauer.com, 413-549-4300). $50.96, 538 pp., 65 illustrations, 7.5" × 10".

This is a very well done work that details various computer programming and bioinformatics concepts. While this may not be the best choice for a casual read, it is a great supplement to the knowledge of experienced programmers. *Practical Computing for Biologists* goes beyond basic introductory level concepts and focuses on such topics as reformatting data, creating graphics, and working with large data sets. Steve Haddock and Casey Dunn thoroughly explain how to confront difficult computing tasks with greater efficiency.

The book begins by answering some basic and predictable questions: how to use this book, how it pertains to biology, as well as indicating which programming language and operating system it will be predominantly using. After the first introductory chapter, the book builds upon previous chapters' concepts at a rapid pace. Each chapter requires access to your computer in order to implement the information learned. As mentioned before, this is not an easy read for the inexperienced layman, so at times certain topics can seem daunting and esoteric. But there are multiple examples scattered throughout this guide as well as resources found in the back appendices that help convey the information. Overall this a well written book that can benefit aspiring bioinformatics or computer programming students by expounding upon previously learned subjects in a efficient and straightforward manner.

—Ben Galindo, Volunteer,
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BOOK NOTICES

Douglas J. Futuyma, H. Bradley Shaffer, and Daniel Simberloff (eds.). 2011. **Annual Review of Ecology, Evolution, and Systematics, Volume 42.** (ISSN 1543-592X; ISBN: 978-0-8243-1442-2, hbk.). Annual Reviews, Inc., 4139 El Camino Way, P.O. Box 10139, Palo Alto, California 94303-0139, U.S.A. (**Orders:** www.AnnualReviews.org, science@annualreviews.org, 800-523-8635, 650-493-4400). $89.00 indiv., 526 pp., 7.25" × 9".

Contents of Volume 42:

1. Native Pollinators in Anthropogenic Habitats—*Rachael Winfree, Ignasi Bartomeus, and Daniel P. Cariveau*
2. Microbially Mediated Plant Functional Traits—*Maren L. Friesen, Stephanie S. Porter, Scott C. Stark, Eric J. von Wettberg, Joel L. Sachs, and Esperanza Martinez-Romero*
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21. Toward an Era of Restoration in Ecology: Successes, Failures, and Opportunities Ahead—*Katharine N. Suding*
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Sabeeha Merchant, Winslow R. Briggs, and Donald R. Ort. 2012. **Annual Review of Plant Biology, Volume 63.** (ISSN 1543-5008; ISBN: 978-0-8243-0663-2, hbk.). Annual Reviews, Inc., 4139 El Camino Way, P.O. Box 10139, Palo Alto, California 94303-0139, U.S.A. (**Orders:** www.AnnualReviews.org, science@annualreviews.org, 800-523-8635, 650-493-4400). $94.00 indiv., 726 pp., 7.5" × 9".

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12. Genome-Enabled Insights into Legume Biology—*Nevin D. Young and Arvind K. Bharti*
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14. Epigenetic Mechanisms Underlying Genomic Imprinting in Plants—*Claudia Köhler, Philip Wolff, and Charles Spillane*
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2012 Application Process, Delzie Demaree Travel Award

Applications for the 2012 Delzie Demaree Travel Award should include a letter from the applicant telling how symposium attendance will benefit his/her graduate work and a letter of recommendation sent by the major professor. The Systematics Symposium (www.mobot.org/MBGSystematicsSymposium) dates for 2012 are October 12–13, 2012. The period for receiving applications will end three weeks prior to the date of the symposium if a sufficient number of applications are in hand at that time. Anyone wishing to apply after that date should inquire whether applications are still being accepted before applying.

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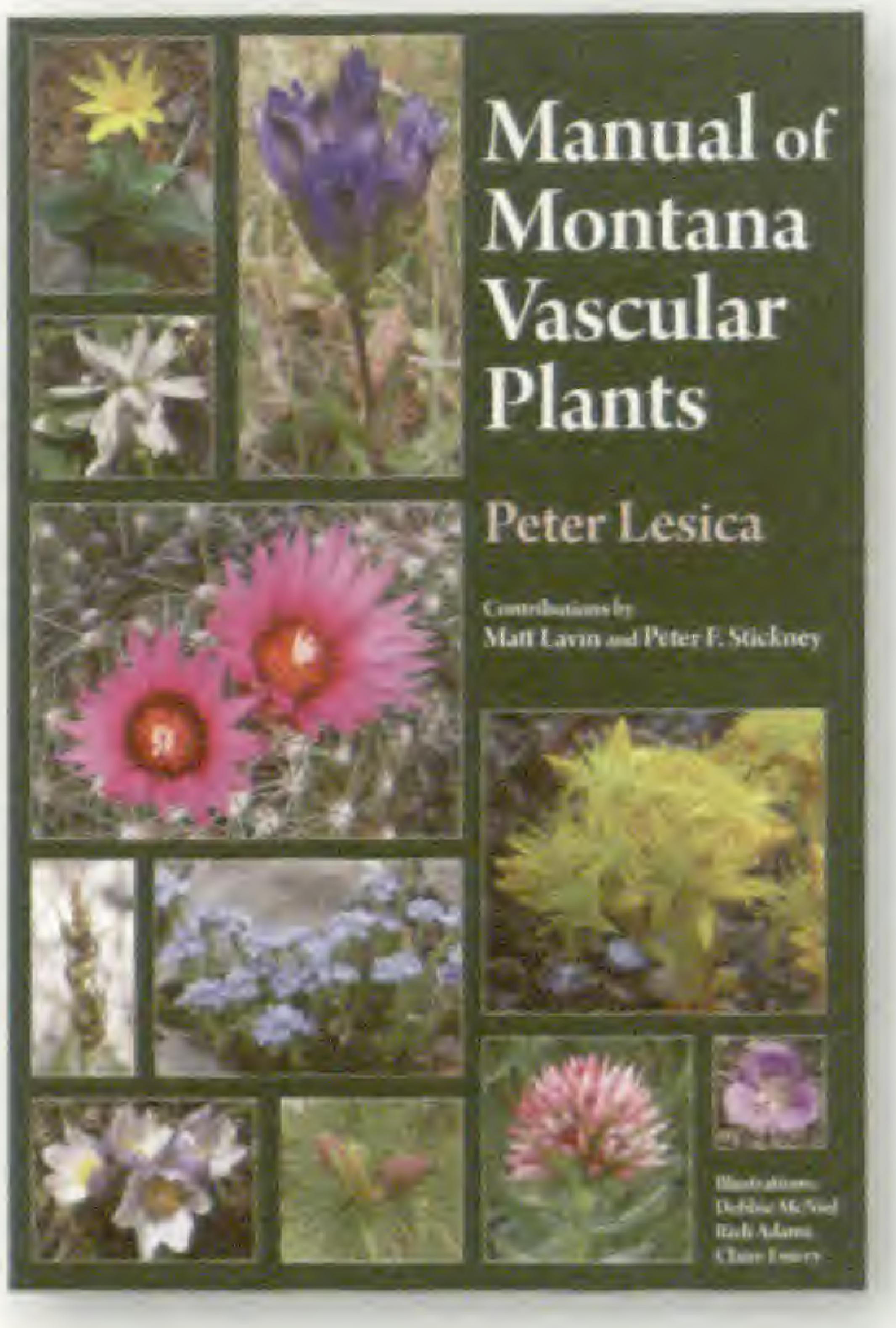
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Manual of Montana Vascular Plants
June 30, 2012

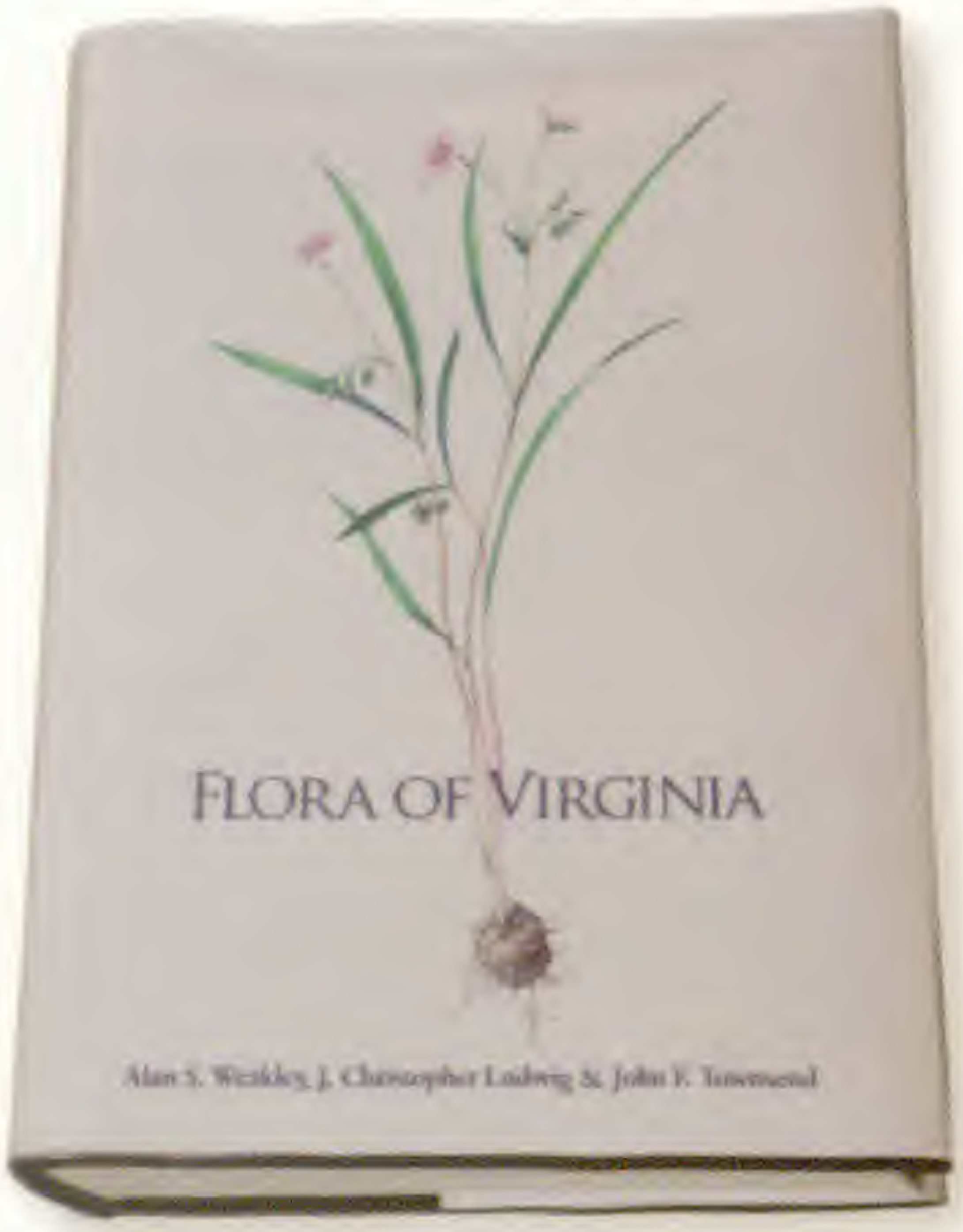
Montana is the fourth largest state in the United States. It includes portions of the Northern Great Plains and the Rocky Mountains. The vegetation of Montana is diverse, due primarily to the size of the state and its great topographic relief which provide strong variation in environmental factors. Montana has a relatively large flora for a northern continental region due to being at the intersection of the Cordilleran, Great Plains and Boreal floristic provinces. This book is a comprehensive field guide to the more than 2,500 species of Montana's vascular plants. It contains descriptions as well as habitat and distribution information based on specimens housed at the state's two major herbaria. Portraits or illustrations of diagnostic structures are provided for nearly one-third of the species.

Lesica, P., with contributions by M. Lavin and P.F. Stickney. Illustrations by Debbie McNiel, Rich Adams, Claire Emery. 2012. *Manual of Montana Vascular Plants*. (ISBN-13: 978-1-889878-39-3, pbk.). Botanical Research Institute of Texas Press, 1700 University Dr., Fort Worth, Texas 76107-3400, U.S.A. (Orders: orders@brit.org, 817-332-4441 ext. 232, fax 817-332-4112, http://www.brit.org/brit-press/books/montana). $50.00, 6.5"×9.5" (pbk), 779 pp., 2000 + maps + 128 plates. $6.00 shipping ($3.00 each additional copy), Outside the U.S.A. contact orders@brit.org, Texas residents add 8.25% to subtotal including postage.

Flora of Virginia (Pre-order)
Expected Publication Date: Fall 2012

Foundation of the Flora of Virginia Project Inc. and Botanical Research Institute of Texas Press are collaborating to publish the *Flora of Virginia*.

The *Flora of Virginia*, with publication targeted for fall 2012, will describe approximately 3,200 taxa in 200 families and feature 1,400 captioned, scaled, and botanically accurate illustrations. Introductory material will include essays on the natural history and vegetation of Virginia and a historical account of botanical exploration in the state, as well as a key to the vascular plant families represented in the Flora. A glossary, bibliography, and comprehensive index will also be provided.



Weakley, A.S., Ludwig, J.C., and Townsend, J.F. 2012. *Flora of Virginia*. (ISBN-13: 978-1-889878-38-6, hbk.). Botanical Research Institute of Texas Press, 1700 University Dr., Fort Worth, Texas 76107-3400, U.S.A. (Orders: orders@brit.org, 817-332-4441 ext. 232, fax 817-332-4112, http://www.brit.org/brit-press/books/virginia). $79.99, 7.5"×10.5" (hbk), 1500+pp., 1400 b/w figures. $6.50 shipping ($3.00 each additional copy), Outside the U.S.A. contact orders@brit.org, Texas residents add 8.25% to subtotal including postage.

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